Appendix D

ARROW BOWEN PIPELINE – ENVIRONMENTAL MANAGEMENT PLAN

OUTLINE WEED MANAGEMENT PLAN

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1 INTRODUCTION

1.1 Project description

The project consists of approximately 580km of pipelines which will convey coal seam gas (CSG) for subsequent export as liquefied natural gas (LNG) and associated above ground infrastructure. The purpose of the project is to deliver CSG from the Arrow Energy Pty Ltd (Arrow Energy) gas fields in the Bowen Basin to a proposed Arrow Energy gas gathering hub in the Aldoga precinct of the Gladstone State Development Area (GSDA) for further transmission to Arrow Energy's proposed Arrow LNG Plant on Curtis Island.

The Arrow Bowen Pipeline (ABP) is currently progressing through the project development cycle. Arrow Bowen Pipeline Pty Ltd (Arrow) is the proponent for ABP project (the project). Arrow has completed and lodged a voluntary environmental impact statement (EIS) and has addressed relevant comments from submissions in a Supplementary Report to the EIS (Arrow 2012). Arrow will prepare and lodge an application for the Petroleum Pipeline Licence (PPL) and associated Environmental Authority (EA).

This Outline Weed Management Plan has been drafted in response to a commitment made in the ABP EIS. Compliance with legislation has been discussed in Section 1.2.

1.2 Legislative context

The Outline Weed Management Plan (WMP) is designed to ensure compliance with the primary legislation in Queensland and the Commonwealth, including the *Land Protection (Pest and Stock Route Management) Act 2002*, *Land Protection (Pest and Stock Route Management) Regulation 2003*, *Fisheries Act 1994*, the *Environment Protection and Biodiversity Conservation Act 1999* and other relevant legislation pertaining to the management of weeds for the Arrow Bowen Pipeline (ABP) project.

The *Land Protection (Pest and Stock Route) Management Act 2002* (LP Act) lists declared species for Queensland. Under the Act, pest species for both plants and animals are classified into three categories.

- Class 1 species are not generally established in Queensland and have potential to cause adverse economic, environmental or social impact. The landowner is obliged to take reasonable steps to keep their land free of Class 1 pest species, unless the owner holds a declared pest permit allowing the pests to be kept on the land.
- Class 2 species are established in Queensland and can cause significant adverse economical, environmental or social impact. The landowner is obliged to take reasonable steps to keep their land free of Class 2 pest species, unless the owner holds a declared pest permit allowing the pests to be kept on the land.
- Class 3 species are established in Queensland and have or could have adverse economical, environmental or social impact. Legislative obligations relating to control of these species are generally limited to specific conservation areas.

The Commonwealth Government identifies Weeds of National Significance (WONS), based on their:

- invasiveness and impact characteristics
- potential and current area of spread
- current primary industry, environmental and socio-economic impacts.

Thirty two WoNS have been identified by the Commonwealth Government based on their invasiveness, potential for spread and environmental, social and economic impacts. A list of twenty WoNS was endorsed in 1999 and a further twelve were added in 2012.

1.3 Purpose

Arrow has statutory and community obligations to uphold and undertake weed management for its operations.

In addition to addressing legislative requirements, the WMP also incorporates the requirements from Arrow's Pest Management Program (May, 2012) (refer to Appendix A). This Program has been developed to both fulfil environmental obligations and to provide strategic direction for the company as it expands. The objectives of the Pest Management Program (the Program) are to:

- provide Arrow with a platform for best practice weed management
- identify how weed management planning fits into Arrow's environmental management planning framework
- identify the objectives in government weed management strategies that Arrow's Pest Management Program should align with, support and follow
- identify the activities that the company currently undertakes, any future activities, and pathways involving human activity that will increase the risk of increasing weeds in the environment
- identify declared weed plant species within, and/or immediately adjacent to Arrow controlled sites
- define the goals, management actions and outcomes to guide the company
- determine the plans, guidelines, procedures and policies to support the Program
- describe the reporting requirements for weed plants and animals to local and state authorities;
- integrate weed management planning into routine work practices by all Arrow staff and contractors
- identify the methods that will be used to evaluate and review the Program.

1.4 Scope

The scope of this Outline WMP is to provide weed management objectives and performance criteria for the project.

The WMP establishes the strategic commitments and principles and management strategies in relation to the control and management of weeds for the project during the construction and operation.

1.5 Objectives and performance criteria

1.5.1 Objectives

The objectives of this WMP are:

- to control and limit the spread of existing weeds along the Right of Way (ROW)
- to prevent new infestations of weeds along the ROW that have potential to impact on biodiversity values along the ROW
- to ensure the health and safety of personnel associated with weed exposure on the ROW.

Performance criteria for managing weeds during construction and operation will be:

- no introduction of new weed species onto the project area
- no spread of existing weed species within the areas affected by the project.

2 SITE REVIEW

Ecological surveys were conducted during the preparation of the EIS and EIS Supplementary Report for the ABP (Arrow 2012). The information gathered during these field surveys were used to prepare this WMP.

2.1 Weeds

Based on the field surveys, a total of 12 weed species (Table 2.1) were identified within the ROW. Further information such as the basic ecology, impacts and other general information on the 12 weed species identified is provided in Appendix C.

Table 2.1: Weed species known to occur within the ROW

Common name	Species name	LP Act status	Weeds of National Significance
Asparagus Fern	*Asparagus aethiopicus*	*Class 3*	*Yes*
Chinee apple	*Ziziphus mauritiana*	*Class 2*	
Common Pest Pear	*Opuntia stricta*	*Class 2*	*Yes*
Creeping Lantana	*Lantana montevidensis*	Class 3	Yes
Giant Rat Tail Grass	*Sporobolus pyramidalis* and *S. natalensis*	Class 2	-
Harrisia Cactus	*Harrisia spp.*	Class 2	Yes
Hymenachne	*Hymenachne amplexicaulis*	Class 2	Yes
Lantana	*Lantana camara*	Class 3	Yes
Mother of Millions	*Bryophyllum delagoense*	Class 2	-
Para Grass	*Urochloa mutica*	-	-
Parkinsonia	*Parkinsonia aculeata*	Class 2	Yes
Parthenium Weed	*Parthenium hysterophorus*	Class 2	Yes
Rubber Vine	*Cryptostegia grandiflora*	*Class 2*	Yes
Resurrection Plant	*Bryophyllum pinnatum*	-	-
Velvety Tree Pear	*Opuntia tomentosa*	*Class 2*	-
Water hyacinth	*Eichhornia crassipes*	*Class 2*	*Yes*

3 POTENTIAL IMPACTS

3.1 Weeds

Potential impacts of invasive weed species include safety hazards, loss of habitat for native plants and animals and subsequent loss of biodiversity. Specific impacts known to be associated with each species are listed in Table 3.1.

Table 3.1: Potential impact of weeds identified

Common name	Species name	Potential impacts
Asparagus Fern	*Asparagus aethiopicus*	This species can reduce biodiversity by suppressing native plant growth and is very hard to manage.
Chinese Apple	*Ziziphus mauritiana*	The species can cause reduction in biodiversity through competing with native plant species. Dense infestations can limit access to area for both native fauna and livestock (DAFF 2012b; DEEDI 2011b).
Common Pest Pear	*Opuntia stricta*	This species can reduce biodiversity by suppressing native plant growth (DAFF 2012d; DEEDI 2011d)).
Creeping Lantana	*Lantana montevidensis*	Lantana is known to be poisonous to livestock and some mild skin irritation can occur from contact with Lantana (CRC 2003). Can suppress growth of native plants.
Giant Rat Tail Grass	*Sporobolus pyramidalis and S. natalensis*	Giant Rat's Tail Grass suppresses native grass species, causing loss of biodiversity. The abrasive nature of the leaves causes dental issues in livestock such as cattle and horses (DAFF 2012g; DEEDI 2011f).
Harrisia Cactus	*Harrisia spp.*	This species can reduce biodiversity by suppressing native plant growth. It is also known to limit the ability to muster stock in areas of high infestation.
Hymenachne	*Hymenachne amplexicaulis*	Hymenachne can increase flooding by reducing the flow capacity of the drainage networks. Hymenachne infestations are also a physical barrier for aquatic and semi-aquatic animals, restricting their territorial movements and breeding activities
Lantana	*Lantana camara*	Lantana is known to be poisonous to livestock and some mild skin irritation can occur from contact with Lantana (CRC 2003). Can suppress growth of native plants.
Mother of Millions	*Bryophyllum delagoense*	Mother of Millions is poisonous to livestock and in some cases are known to cause significant numbers of cattle deaths.
Para Grass	*Urochloa mutica*	Para Grass invades areas of disturbed remnant vegetation on suitable soils and cane-growing areas and is a very aggressive invader, significantly displacing native plants.
Parkinsonia	*Parkinsonia aculeata*	Dense infestations can limit access to areas for both native fauna and livestock particularly around water sources
Parthenium Weed	*Parthenium hysterophorus*	Parthenium Weed is known to dominate pastures and suppress native species. The pollen from this plant is also a potential allergen that can cause dermatitis and hay fever in humans (DAFF 2012h; DEEDI 2011g).

Common name	Species name	Potential impacts
Resurrection Plant	*Bryophyllum pinnatum*	Resurrection plant can form dense populations in natural habitats (i.e. in open woodlands and wetter forests, in coastal environs and along waterways), replacing native species and preventing their regeneration.
Rubber Vine	*Cryptostegia grandiflora*	Rubber vine can reduce biodiversity by suppressing native plant growth. Dense infestations can limit access to areas for both native fauna and livestock (DAFF 2012e; DEEDI 2011e).
Velvety Tree Pear	*Opuntia tomentosa*	This species can reduce biodiversity by suppressing native plant growth (DAFF 2012d; DEEDI 2011d)).
Water Hyacinth	*Eichhornia crassipes*	Forms dense, impenetrable mats over the water surface. Specific impacts include: blocking irrigation channels and rivers, restricting livestock access to water, destroying natural wetlands, eliminating native aquatic plants, reducing infiltration of sunlight, changing the temperature, pH and oxygen levels of water, reducing gas exchange at the water surface.

4 WEED MANAGEMENT ACTIONS

4.1 Roles and responsibilities

Table 4.1 details the roles and responsibilities of the various stakeholders related to the management and actions of this WMP.

Table 4.1: Management and monitoring roles and responsibilities

Role	Responsibility
Arrow	Manage weed control programs and maintain records
EPC Contractor	The EPC Contractor will have to develop a strategy for managing weeds. It will be their responsibility to complete at least the following: ▪ develop a weed management plan consistent with the Arrow Weed Outline Plan ▪ install and operate weed wash downs along the ROW, including certification of vehicles associated with construction ▪ undertake inspections to identify, treat and evaluate weeds growing during the construction and warranty periods ▪ engage contractors to spray and control weeds ▪ maintain records of treatments, chemicals and methods and results.
Weed contractor	Implement weed and pest control activities in accordance with legislative requirements and ensure required specifications outlined in this procedure are met. Keep required records of inspections and activities as outlined in this procedure.

4.2 Weed prevention measures

4.2.1 Weed wash down

Vehicles and machinery have a high potential to spread weeds and introduce new weed species into the ROW. Seeds and other reproductive material of plants can be transported in contaminated vehicles.

All vehicles and plant must be washed down by vehicle operators consistent with the Queensland *Checklist for Cleandown Procedures* (DNR 2000a) and certified weed free by trained personnel. Trained personnel will assess vehicles, plant and equipment following cleaning and issue 'written notice' in accordance with the LP Act. Vehicles (including transporters and earthmoving equipment), entering or operating on the ROW, will be required to produce a valid written notice demonstrating weed free status upon request. A register will be maintained of vehicles, plant and equipment cleaned. Locations for washdown facilities will be identified prior to construction and will be strategically located throughout the alignment where weed free zones have to be traversed. Fixed washdown facilities will be constructed in accordance with *Queensland Guidelines for the Construction of Vehicle and Machinery Washdown Facilities* (DNR 2000b).

4.2.1 Weed hygiene declaration

Weeds and their reproductive material can also enter a location through the transportation of soil, gravel and other materials. All machinery and material being imported to the project or travelling between areas of the ROW will be required to have a valid Weed Hygiene Declaration and be recertified when travelling from and to known weed areas.

4.3 Weed control methods

Table 4.2 lists weed species known to occur within the ROW and indicates their appropriate control method and the level of priority given to the need for control. The priority of control is based on the following:

- Low – Species that are Class 3 weeds and have the potential to cause health concerns for livestock
- Medium – Species that are Class 3 weeds or species that are known to cause health concerns to personnel or livestock and that without controls have the potential to negatively impact on biodiversity of the project
- High – Weeds of National Significance (WONS) and any Class 2 declared weed species that are required to be controlled under the LP Act, and are known to be highly invasive and some species have the potential to cause health concerns to personnel and livestock and without controls will have a negative impact on the biodiversity within the project.

Table 4.2: Treatment priority and methods for weeds

Weed species	Priority	Herbicide application	Manual removal	Integrated management
Asparagus Fern	High	✓	✓	✓
Chinee Apple	High	✓	✓	✓
Common Pest Pear	High	✓	✓	✓
Creeping Lantana	High	✓	✓	✓
Giant Rat Tail Grass	High	✓	✓	✓
Harrisia Cactus	High	✓	✓	✓
Hymenachne	High	✓	✓	✓
Lantana	High	✓	✓	✓
Mother of Millions	High	✓	✓	✓
Para Grass	Medium	✓	✓	✓
Parkinsonia	High	✓	✓	✓
Parthenium Weed	High	✓	✓	✓
Resurrection Plant	Medium	✓	✓	✓
Rubber Vine	High	✓	✓	✓
Velvety Tree Pear	High	✓	✓	✓
Water Hyacinth	HIgh	✓	✓	✓

4.3.1 Integrated management

Integrated weed management is a preferred method of controlling weeds within the ROW. The idea of integrated management is to use a variety of control methods to accomplish the objectives of the WMP. The integrated management method is ideal to use across broad areas that may be constrained by a number or environmental, safety or other concerns that a single management option is insufficient to work effectively and address the concerns.

This method also prevents extensive environmental damage that may result from over use of herbicides or frequent fire control (DAFF 2010). Further this method can prevent the weeds from becoming resistant to herbicides and in some case can reduce the cost of controlling weeds within an area (DAFF 2010).

4.3.2 Manual removal

Where feasible, in areas of infestation that involve isolated individuals, manual removal is an effective method of eradicating the infestation. The overall success of manual removal of weeds is based on the ability to remove any material that may result in regeneration of the species; this includes but is not limited to root systems, branches, leaves, seeds and other reproductive material. This method has a high labour cost and also has the requirement for high skill- intensity, as there is a requirement to identify young plants and seedlings for removal.

This method is best applied to areas where the species have only recently started to occur or at the end of an intensive treatment regime where there is only isolated plants occurring. For the best results it is recommended that the treatment area is followed up with an appropriate herbicide treatment to ensure that seedlings and germinated seeds are controlled before they mature.

4.3.3 Herbicide application

Herbicide application is the most commonly used control method for weed species. Herbicide application has proven effective at controlling major and minor infestations of weeds. Herbicide treatments are commonly used in conjunction with other control methods or repeat applications.

Herbicide application requires trained, competent and qualified personnel to implement the method. Herbicide applications have several safety and environmental considerations that need to be addressed and therefore herbicides should only be used as directed by the product label and all safety procedures and warnings detailed in the Material Safety Data Sheet (MSDS) should be adhered throughout any application treatment. Further all herbicides to be used on site in weed management will adhere to the relevant requirements under the *Agricultural and Veterinary Chemicals Code Act 1994*.

4.3.1 Personal protective equipment

Any application of herbicides shall be applied utilising the required personal protective equipment (PPE) as recommended in the MSDS.

5 RECORDS, MONITORING AND REVIEW

5.1 Roles and responsibilities

Table 4.1 details the roles and responsibilities of the various stakeholders related to the recording, monitoring and review actions of this WMP.

5.2 Records

Records should be kept from all weed control activities e.g. herbicide application. Where Arrow utilises the relevant landholder to undertake weed management in line with their respective property weed control measures, records of such weed management and payments shall be maintained. These records should be kept for a minimum of five years so to allow for a comprehensive review of the WMP. The minimum should be recorded for the control events:

- date
- location of activity
- target species
- method utilised
- amount of herbicide/ utilised
- area treated
- numbers/area successfully controlled.

5.3 Monitoring and review

Monitoring will be required to determine the current presence of weed species and their abundance within the ROW. This should occur monthly during construction and then annually for a period of two years following construction. Following the two year period, the frequency of monitoring should be reconsidered dependent on the success of control measures and the level of infestations. This monitoring should allow for identification of any new species or outbreak areas. This monitoring should further be able to determine the success or short comings of the management actions that have been implemented. Any significant findings, such as new weed species, new outbreaks or any actions resulting from incidents, from the monthly and annual monitoring will be incorporated into an annual review of the WMP. This annual review should focus on the success of current management actions and, where required, evaluate the priority of species to be controlled or new species that require control.

It is recommended that a major review of the WMP is conducted once every two years to evaluate the currency and effectiveness of the WMP. This review should incorporate a review of the current WMP, review of records of management actions e.g. contractor records, past reviews and past mapping of weed outbreaks. The monthly monitoring of weed species during construction and annual monitoring during operation can be used to inform the major review. It is further recommended that this review be conducted by an independent consultant.

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Appendix A. Arrow's Pest Management Program

PEST MANAGEMENT PROGRAM

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Arrow Energy
Pest Management Program

May 2012

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TABLES

APPENDICES

1.0 INTRODUCTION

Arrow Energy (Arrow) is expanding its petroleum activities to become one of Australia's leading Liquefied Natural Gas (LNG) exporters. As a leading coal seam gas company, Arrow aims to be a leader in all aspects of best practice environmental management, including pest management. Arrow has environmental obligations to uphold and has been undertaking pest management on its properties and for its domestic operations. This Program has been developed to both fulfil environmental obligations and to provide strategic direction for the company as it expands.

The purpose of the Program is to:

- provide Arrow with a strategic platform to become an industry leader in best practice pest management
- identify the objectives for pest management planning consistent with national, state and local pest management requirements
- identify actions to be implemented by Arrow that are consistent with various planning strategies
- provide strategic direction in relation to pest management for Arrow as it expands.

As a resource tenure holder, Arrow has an obligation to manage pest plant and animal species on their controlled sites. This Program considers potential pest plants, animals and biosecurity risks to Arrow controlled sites, focusing on upstream and midstream activities. Pest management for the LNG project has been developed in the document 'Arrow LNG plant - Terrestrial Ecology Pest Management Plan' (Ecosure, 2011) as part of Arrow's LNG Plant Terms of Reference and Environmental Impact Statement requirements.

The state of Queensland has identified that '*weeds have a significant adverse impact on primary production, ecosystem biodiversity, and conservation values of the state*' (State of Queensland, Department of Primary Industries, 2008). Weeds impact severely on agriculture by competing with production, contaminating produce and poisoning livestock. Weeds also impact on biodiversity by out competing native plants and degrading habitat. Weeds, along with other invasive species, pose one of the most significant threats to biodiversity (Australian Government Department of the Environment and Water Resources, 2006). Weeds can also cause severe allergic reactions in people, increasing the cost of public health in Australia (Australian Government Department of the Environment and Water Resources, 2006).

Pest animals can be either native or exotic animal species that have an adverse impact on the community and the environment (Department of Natural Resources and Mines, 2002). Pest animal impacts cause damage to the environment thorough the increase of weed spread and land degradation. Agriculture and pastoral activities are also severely impacted by pest animals (Natural Resource Management Ministerial Council, 2007).

1.1 Objectives of the Program

The objectives of the Pest Management Program (the Program) are to:

- Provide Arrow with a platform for best practice pest management
- Identify how pest management planning fits into Arrow's environmental management planning framework
- Identify the objectives in government pest management strategies that the Company's Pest Management Program should align with, support and follow
- Identify the activities that the company currently undertakes, any future activities, and pathways involving human activity that will increase the risk of increasing pests in the environment

- Identify declared pest plant and animal species within, and/or immediately adjacent to Arrow controlled sites
- Define the goals, management actions and outcomes to guide the company
- Determine the plans, guidelines, procedures and policies to support the Program
- Describe the reporting requirements for pest plants and animals to local and state authorities.
- Integrate pest management planning into routine work practices by all Arrow staff and contractors.
- Identify the methods that will be used to evaluate and review the Program.

1.2 Developing the Program

This Program was developed in response to a requirement under the Level 1 Environmental Authority for some tenements it currently operates under. Arrow recognises the importance of pest management as it relates to their activities, is committed to developing a Pest Management Program that covers all relevant legislative and best practice requirements and is aligned to Commonwealth and State strategies, as detailed in this Program. This Program should be used to identify the strategic framework within which Arrow manages pests. Specific Arrow pest information is covered in some detail in the report and in relevant Appendices.

The Action Plan (Appendix C) is a critical part of this Program and has been developed based on consultation of Arrow personnel, and to meet legal obligations. The Action Plan identifies management actions being undertaken and proposed in future projects. The Action Plan and will be a continually evolving document.

1.3 Consultation

The Program will be used to inform relevant stakeholders (such as landholders, local government, state government) of methods that Arrow is employing for pest management. External feedback, where relevant, will be assessed and incorporated into the Program.

1.4 Finalisation and Implementation

The final Program will be implemented into the company's operations for all project phases from exploration to site decommissioning.

1.5 Monitoring and Review

The Program will be reviewed on an annual basis, with more frequent six monthly reviews for progress against the Action Plan. Based on completion of actions, issues identified, emerging pests and changes to operations the Program will be revised and updated as and when required.

2.0 GEOGRAPHIC EXTENT OF PROGRAM

Arrow operates predominantly within Queensland and is currently conducting exploration activities in northern New South Wales (NSW). Arrow's individually and jointly operated exploration and production tenements cover an area of 85,242km^2 in Queensland and 7,076 km^2 in NSW. This area includes 30 local council shires in Queensland and 8 in NSW (Figure 1).

Currently, there are two production fields in Queensland; one field located south of Dalby and the other located at Moranbah in central Queensland. Exploration activities are occurring in the Bowen, Surat, Clarence/Moreton and the coastal geological basins. Results of exploration and appraisal activities will determine future well field development. Two major gas transmission pipelines are planned to link the well fields in the Surat and Bowen basins to the proposed LNG plant on Curtis Island, near Gladstone in central Queensland.

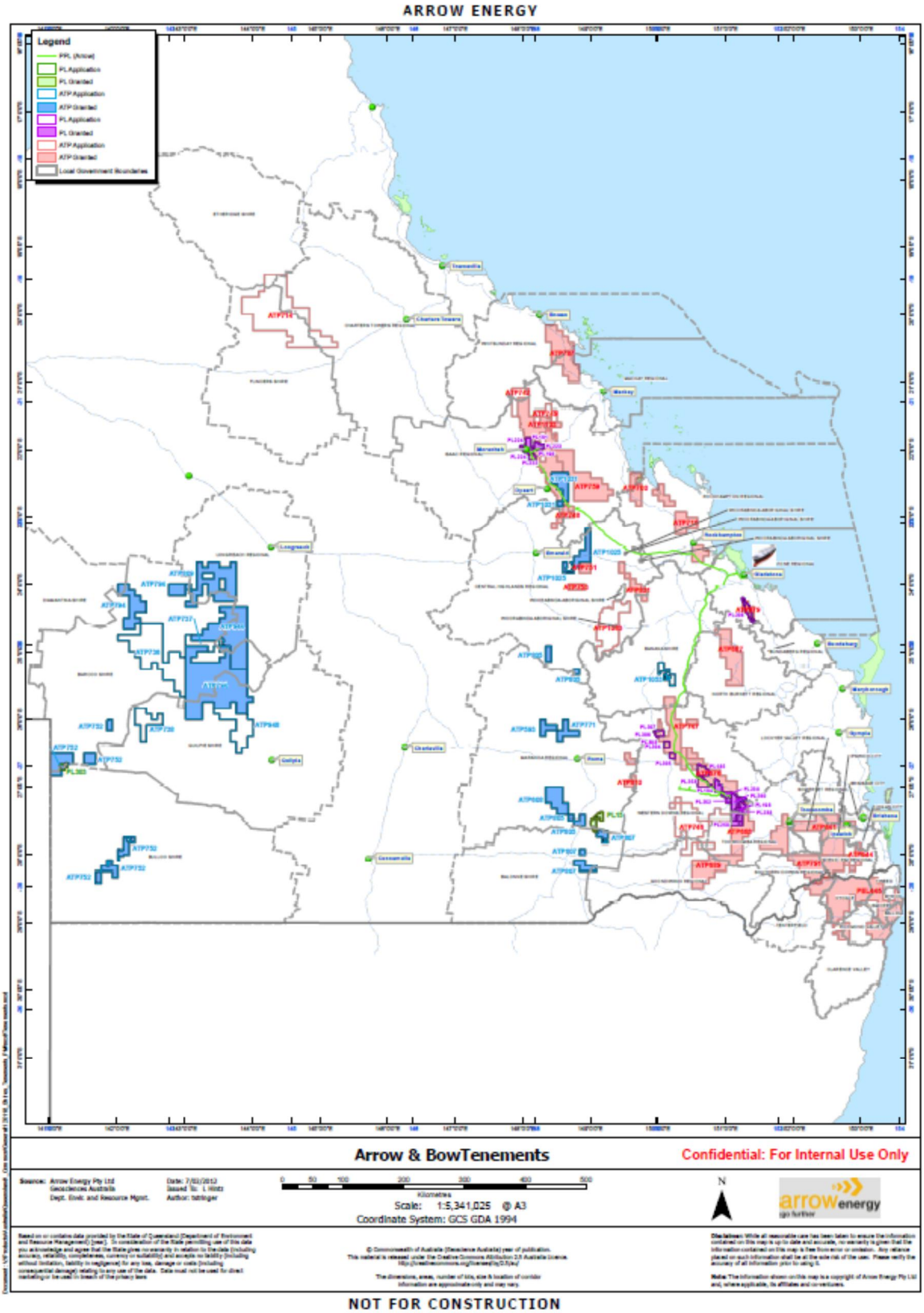

Figure 1: Extent of Arrow Energy exploration and production Tenements as of January 2012

3.0 ENVIRONMENTAL FRAMEWORK

Arrow is in the process of developing a Health, Safety and Environment Management System (HSEMS) that will incorporate the existing Environmental Management System and Occupational Health and Safety System. Currently the framework of the system defines that pest management will be addressed by the Biodiversity Standard (HSEMS 2.1, Draft). The intent of the standard is to protect and enhance biodiversity in the areas in which Arrow operates recognising the values of healthy, functioning terrestrial and aquatic natural systems.

This Program has been developed to achieve the environmental objectives of the standard and it aims to provide the framework for planning pest management actions to align with the relevant national, state and local pest management plans and strategy objectives. This framework (Figure 2) is at early developmental stages and it will continue to evolve over the next 18 months.

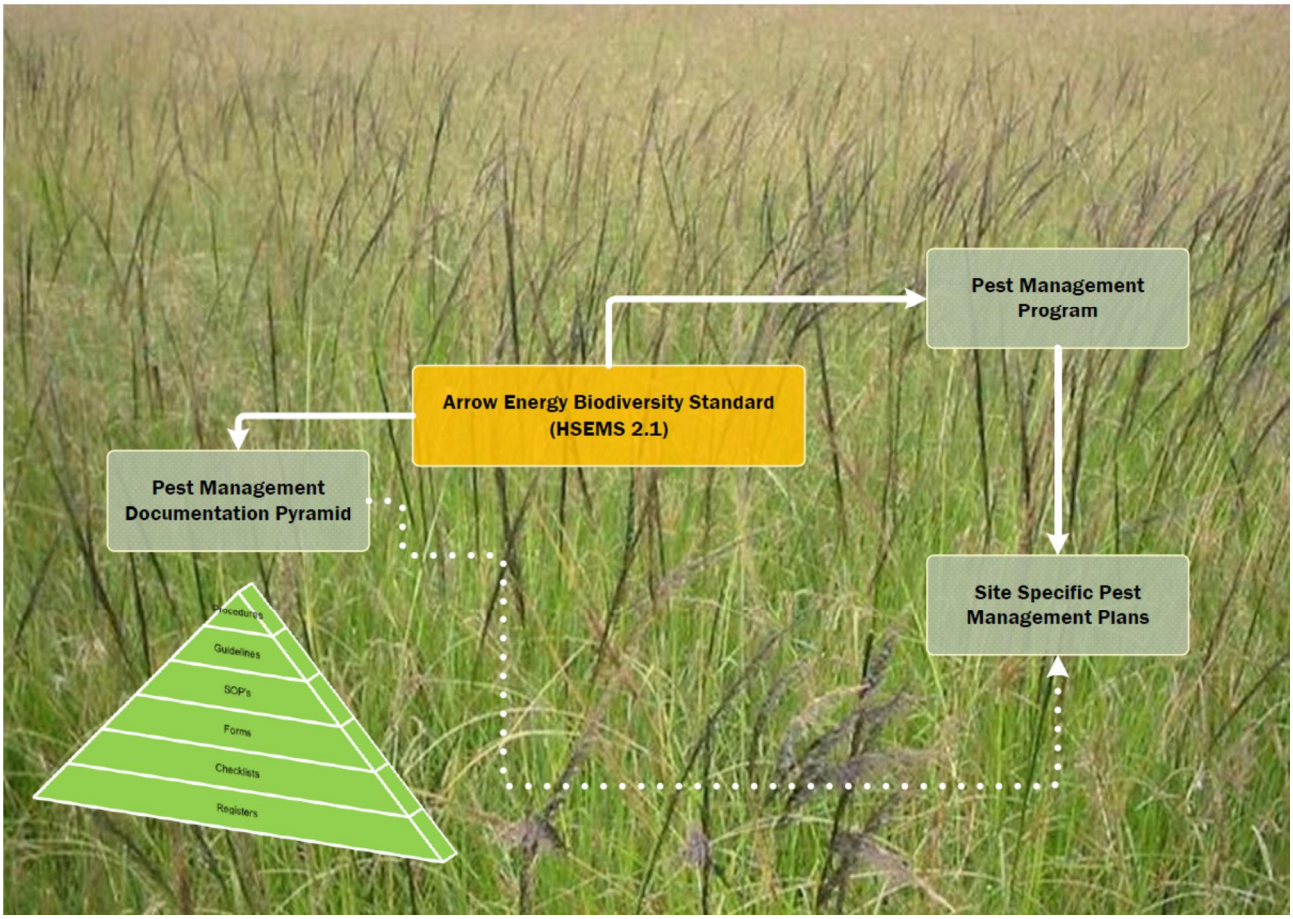

Figure 2: Arrow Environmental Framework

4.0 ARROW ACTIVITIES THAT COULD CONTRIBUTE TO PEST SPREAD

All exploration, appraisal, production, processing and gas transmission activities have the potential to increase pest species on a site. This could occur through pest being introduced or their abundance increasing at a specific location. A summary of activities conducted by each of the phases is included in Table 1.

Table 1 Arrow activities potentially contributing to pest spread at different project phases

	Project Phases							
Activities	Site preparation	Exploration	Appraisal program	Construction phase	Land access and approval stage	Drilling phase	Production Phase	Decommissioning phase
Site selection and surveys	✓	✓						
Mobilisation to site, including vehicle movements through properties	✓	✓	✓	✓	✓	✓		✓
Site clearance, including slashing, vegetation removal, soil disturbance.	✓	✓	✓	✓		✓		
Establishment of access	✓	✓		✓			✓	✓
Equipment deliveries		✓	✓	✓		✓		✓
Handover to surveyors		✓						
Collection of core samples		✓						
Import of materials	✓		✓	✓			✓	
Installation of flow lines and management of frac water			✓			✓	✓	
Decommissioning and removal of equipment			✓					✓
Operation and monitoring of holding dam			✓			✓	✓	
Site preparation including operation of borrow pit, importing fill, general soil disturbance, vegetation clearance	✓		✓	✓			✓	✓
Installation of security and dam fencing				✓				
Trenching and laying conduit				✓				
Dam construction				✓				
Access track construction		✓		✓		✓	✓	
Top soil removal and stockpiling, general soil disturbance	✓						✓	✓
Well site and road drainage			✓	✓		✓		✓

	Project Phases							
Activities	Site preparation	Exploration	Appraisal program	Construction phase	Land access and approval stage	Drilling phase	Production Phase	Decommissioning phase
Pit drying								✓
Revegetation								✓
Initial site inspection and baseline identification	✓		✓		✓			
Ecological and cultural heritage inspection	✓		✓		✓			
Turkeys nest excavation and construction						✓		
Security fencing						✓		
Deliveries, including equipment and fuel						✓	✓	✓
Drilling mud management						✓	✓	
Rehabilitation of soil surface and monitoring						✓		✓
Delivery of Arrow stores equipment to site		✓		✓		✓	✓	
Collecting of remaining equipment at completion		✓		✓		✓		✓
Constructing and maintaining pipelines				✓			✓	
Well maintenance							✓	
Dam operating and maintenance							✓	
Low point drains							✓	
Pipelines at creek crossings							✓	

The Program applies to activities relating to constructing, operating, decommissioning and rehabilitating stages and phases of the project. Weeds and pest animals can be successful at establishing and spreading in new areas because they respond to disturbance and are able to out compete native species. The causes of disturbance include vegetation clearing, changing land uses and developing favourable conditions for different species to thrive.

All Arrow staff and contractors undertaking site activities will contribute to managing pest species. This Program will identify the framework to control and manage pests and their impacts.

The major pathways for weed spread for Arrow are identified in Table 2, and have been based on major pathways for weed spread identified in the Queensland Weed Spread Prevention Strategy (Queensland Department of Primary Industries and Fisheries, 2008).

Table 2: Potential pathways for pest spread from Arrow activities

Potential Pathway	Details
Transportation over land and water	▪ Vehicle and machinery movement - cars, trucks, drilling equipment, construction equipment. ▪ Vegetation clearing and ecosystem disturbance – spread through wind, rain, flood waters.
Moving material	▪ Importing materials – vegetation, soil, construction materials, rehabilitation products. ▪ Excavating or extracting materials – soil, sand.
Disturbing ecosystems	▪ Vegetation clearing, landscaping ▪ Habitat construction or destruction ▪ Revegetation
Storing and disposing waste	▪ Removal of weed waste ▪ Removal of cleared vegetation

5.0 HOW THE PROGRAM WILL ADDRESS LEGAL OBLIGATIONS AND AUSTRALIAN BEST PRACTICE PEST MANAGEMENT

The framework for pest management in Australia is managed, influenced and guided by:

- International conventions and treaties to which Australia is a signatory or partner.
- Commonwealth, National and Local legislation, strategies and policies.

There are various levels of relevance under the international conventions and treaties and legislation to Arrow operations and the context of this Program. In compiling this Program, a review of all requirements for Australia generally, Queensland and New South Wales have been considered. Where deemed relevant specifically to Arrow operations and the context of this Program, details of requirements have been included as a summary in this section and incorporated into resulting actions where gaps have been identified.

5.1 National and International Obligations and Strategies

Environmental Protection and Biodiversity Conservation Act

The Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) deals with key threatening processes that may threaten the survival, abundance or evolutionary development of a native species or ecological community. The EPBC Act defines a process for the development of threat abatement plans (TAPs) to research and identify appropriate management for the identified key threatening processes. TAPs are widely consulted prior to finalising and can deal with threatening processes to native flora and fauna from pest flora and fauna. TAPs will generally set a national framework for coordinating response efforts to deal with the identified key threatening processes (Commonwealth Department of Sustainability, Environment, Water, Population and Communities, 2011).

Managing species listed under approved TAPs and identified as potentially relevant to Arrow operations are also dealt with under state legislation included in Appendix B.

Convention on Biological Diversity

Australia is a signatory to the Convention on Biological Diversity (CBD). The CBD has three main objectives (Text of the Convention on Biological Diversity, 2011):

1) The conservation of biological diversity

2) The sustainable use of the components of biological diversity

3) The fair and equitable sharing of the benefits arising out of the utilization of genetic resources

The management of pests and weeds assists with conserving biological diversity in for Arrow operations in Australia.

Australian Weeds Strategy

The Australian Weeds Strategy identifies a framework to establish consistent guidance for all parties, including industry. It identifies priorities for weed management with the aim of minimising the impact of weeds on Australia's environmental, economic and social assets. The Australian Weed Strategy identifies several objectives and outcomes to be addressed in this Program, which are summarised in
Table 3.

Table 3: Objectives and Outcomes of the Australian Weeds Strategy (Source: National Resource Management Ministerial Council, 2006)

National Objectives	Outcomes
1.2 Prevent early detection of, and rapid action against, new weeds.	New weeds are detected at an early stage of establishment. New weed incursions are identified and addressed. Organisations have response plans in place. Weeds are rapidly and accurately identified
1.3 Reduce the spread of weeds to new areas within Australia	Weed spread to new areas is minimised.
2.2 Implement coordinated and cost effective solutions for priority weeds and weed problems.	Weed impacts are reduced through improved management practices.
2.3 Develop approaches to managing weeds based on the protection of values and assets.	Communities manage weeds at a coordinated and whole of landscape level. Assets are protected and restored
	Appropriate systems are adopted for sustainable land management.
3.1 Raise awareness and motivation among Australians to strengthen their commitment to act on weeds.	Industries, public agencies and communities adopt weed spread prevention practices.
3.2 Build Australia's capacity to address weed problems and improve weed management.	Weed management is undertaken with increased skill and knowledge. Improved weed management is achieved through increased knowledge and new techniques.

This Program adopts principles developed in alliance with the Australian Weeds Strategy:

1) 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.

2) Combating weed problems is a shared responsibility that requires all parties to have a clear understanding of their roles.

3) Good science underpins the effective development, monitoring and review of weed management strategies.

4) Prioritisation of and investment in weed management must be informed by a risk management approach.

5) Prevention and early intervention are the most cost effective techniques for managing weeds.

6) Weed management requires coordination among all levels of government in partnership with industry, land and water managers and the community, regardless of tenure.

7) Building capacity across government, industry, land and water managers and the community is fundamental to effective weed management.

The Weeds of National Significance

The Weeds of National Significance (WoNS) program coordinates the national effort against 20 of Australia's worst invasive plants. The impact of these weeds and methods to reduce their impact are coordinated at the national level. Each of the weeds has a national strategy with specific actions, which has been endorsed by the Natural Resource Management Ministerial Council. Coordinating these strategies at a national level is important to encourage consistent management across states, improve the links from research to on-ground control, and consolidate commitments from a wide range of stakeholders (Weeds Australia, 2012).

National Environmental Alert List

The National Environmental Alert List complements the WoNS List and identifies non native weed species that have established naturalised populations in the wild. Species were identified based on the following criteria (National Environmental Alert List, 2012):

- posing a high or serious potential threat to the environment
- having limited distribution within Australia at present
- being amenable to successful eradication or containment programs

Australian Pest Animal Strategy

The vision for the Australian Pest Animal Strategy is that Australia's biodiversity, agricultural assets and social values are secure from the impacts of vertebrate pest animals. The focus of the Strategy is to address the undesirable impacts caused by exotic vertebrate animals (mammals, birds, reptiles, amphibians, and fish) that have become pests in Australia, and to prevent the establishment of new exotic vertebrate pests.

The Australian Pest Animal Strategy identifies goals and objectives that is to be addressed in this Program, which are summarised in
Table 3.

Table 4: Goals and Objectives relevant to Arrow from Australian Pest Animal Strategy (Source: Natural Resource Management Ministerial Council, 2007)

Goal 1 Provide leadership and coordination for the management of pest animals	Objective
	1.1 To develop the capacity and processes for effective delivery of pest animal management.
	1.3 To improve public awareness of pest animals, research coordination and its support for pest management at the national level, and adoption of best practice management methods.
Goal 2 Prevent establishment of new pest animals	Objective
	2.1 To prevent the introduction of new animals with pest potential.
	2.2 To ensure early detection of, and rapid response to, new incursions of exotic animals.
	2.3 To reduce the spread of pest animals to new areas within Australia.
Goal 3 Manage the impacts of established pest animals	Objectives
	3.1 To identify established pest animals of national significance.
	3.2 To identify and manage the impacts of pest animals on key assets.
	3.3 To coordinate management of established pest animals across Australia.

5.2 State Obligations and Strategies

5.2.1 Queensland

Environmental Protection Act 1994

The responsibility for environmental management, approval and regulation of the resources industry in Queensland rests largely with the Department of Environment and Resource Management (DERM), as outlined under the *Environmental Protection Act 1994.*

Petroleum activities (including coal seam gas (CSG) and conventional oil and gas) are Chapter 5A activities under the *Environmental Protection Act 1994* (Section 309A) and require an environmental authority to be issued before the activity can be carried out.

The environmental authority imposes conditions aimed at ensuring that potential environmental harm is minimised or mitigated. These conditions have included the requirement for Arrow to develop and implement a Pest Management Program.

Environmental Authorities issued under Queensland Legislation require that an effective Pest Management Program be developed and implemented that includes, but is not limited to:

a) Identification of pest species and infestation areas;

b) Prevention and/or minimisation of the introduction and/or spread of pests;

c) Control and management of pest outbreaks as a result of petroleum activities;

d) Details of community consultation in developing the Pest Management Program; and

e) Considers the Petroleum Industry (including coal seam methane gas) Minimising Pest Spread Guidelines, (Department of Primary Industries and Fisheries, 2008).

The development and implementation of this plan in intended to meet the requirement of this condition.

Land Protection (Pest and Stock Route Management) Act 2002

The *Land Protection (Pest and Stock Route Management) Act 2002* (LP Act) specifies requirements for the management of pests on land and on the stock route networks. The LP Act allows for the declaration of plants and animals that are considered serious or potentially serious pests in Queensland. It also requires that Local Governments develop a Pest Management Plan for their Shire or Region. Local Government Pest Management Plans are discussed in more detail in Section 5.3. The declaration class categories are summarised in Table 5.

Table 5: Qld Declaration Classes under the LP Act (Source: Department of Primary Industries and Fisheries, 2011)

Class Category	Weed Type	Landholder legislative requirements
Class 1	Class 1 pests have the potential to become serious pests in Queensland. The focus is to prevent introduction, possession and sale.	Landholder must keep land free of Class 1 pests. It is a serious offence to introduce, keep, release or sell Class 1 pests without a permit.
Class 2	Class 2 pests have already spread in Queensland, however their impact is so significant that further spread and control is required.	Landholders must try to keep their land free of Class 2 pests. It is an offence to possess, sell or release these pests without a permit.
Class 3	Class 3 pests are commonly established in Queensland. Control is not required unless there is actual or potential impact on an environmentally significant area.	It is an offence to sell, introduce, release or supply a Class 3 pest.

Plant Protection Act 1989

The *Plant Protection Act 1989* (PP Act) focuses on the management of threats to plants in Queensland from pests through prevention, control or removal. Pests declared under the PP Act include plants, invertebrates, virus or diseases.

Biosecurity Bill 2011

New Biosecurity legislation based on a single, cohesive Biosecurity Act and new subordinate legislation is being developed for Queensland. The *Biosecurity Bill 2011* removes obsolete, repetitive, contradictory or unnecessarily obstructive elements from the current regulatory framework to meet biosecurity objectives. Existing legislation that is relevant to this Program will be replaced as part of the new legislation. This includes, but is not limited to:

- *Land Protection (Pest and Stock Route Management) Act 2002*, Land Protection (Pest and Stock Route Management) Regulation 2003 (apart from provisions dealing with the management of the stock route network and exhibited animals)
- *Plant Protection Act 1989*, Plant Protection Regulation 2002 and Plant Protection (Approved Sugarcane Varieties) Declaration 2003, Plant Protection (Branched Broomrape) Quarantine Notice 2008, Plant Protection (Mango Malformation Disease) Notice 2008, Plant Protection (Mango Malformation Disease) Quarantine Notice 2008, Plant Protection (Vegetable Leafminer - Movement Prohibition) Notice 2008 and Plant Protection (Vegetable Leafminer - Pest Declaration) Notice 2008.

The *Biosecurity Bill 2011* (the Bill) has been drafted to:

- enhance the biosecurity capability of government and stakeholders
- improve biosecurity governance and accountability
- provide scalable instruments to be used across the biosecurity continuum
- reduce regulatory burden and administrative overheads.

The Bill was introduced to Cabinet in October 2011 and referred to the Environment, Agriculture, Resources and Energy Parliamentary Committee for consideration (Queensland Government, 2012).

Queensland Weed Spread Prevention Strategy

The Queensland Weed Spread Prevention Strategy has been developed to minimise the spread of new weeds into Queensland. Goals identified by the strategy that are relevant to this Pest Management Program are included in Table 6.

Table 6: Goals relevant to Arrow from the Queensland Weed Spread Prevention Strategy (Source: Queensland Department of Primary Industries and Fisheries, 2008)

Goal	Outcome	Management actions
Goal 1: Incorporate policy and actions to prevent weed spread into the work practices of industry and organisations.	1.2 Weed spread prevention is incorporated into existing industry and government standards and programs.	Include weed spread prevention measures in industry induction procedures.
Goal 3: Identify and protect clean areas	3.3 A culture of cleaning vehicles and machinery is established, and a network of strategically located clean-down facilities is developed across Queensland	3.3.1 Audit existing facilities to determine: ▪ Adequate waste disposal ▪ Water usage ▪ Occupational health and safety ▪ Effectiveness in removing weed reproductive material.

Goal	Outcome	Management actions
		3.3.2 develop and implement state management policy for clean down facilities including: clean down facilities, criteria for portable facilities
	3.4 Clean and infested areas are identified and mapped for priority weed species	3.4.1 Develop and utilise a standardised system for identifying and mapping the location of weed species.
	3.5 Purchasers are informed of the weed status of products and land	3.5.1 Promote awareness and wide use of Weed Hygiene Declarations.
	3.8 Key corridors are identified and managed to prevent or minimise weed spread	3.8.1 Adopt a risk management approach to manage weeds on roads, riparian areas and other areas considered as corridors for weed spread
Goal 5: Resource and coordinate consistent actions within the state and work towards achieving consistency with other states and territories	5.2 Major stakeholders are actively involved in the development of weed spread prevention initiatives	5.2.2 Stakeholder participation actively sought to implement outcomes
Goal 6: Maintain a strong legal foundation for weed spread prevention	6.1 Weed seed spread provisions of the Land Protection (Pest and Stock Route Management) Act 2002 are complied with	6.1.1 Enforce weed spread provisions of the Land Protection (Pest and Stock Route Management) Act 2002 6.1.2 Undertake awareness campaigns to improve compliance
	6.4 Audit processes that ensure weed spread prevention is practised are investigated for feasibility	6.4.1 Examine the feasibility of enforceable audit processes for established guidelines such as industry codes of practice
Goal 7: Review, monitor and evaluate actions to achieve continuous improvement	7.2 The effectiveness of management actions in preventing weed spread is monitored and assessed	7.2.1 Include monitoring and evaluation components in all implementation plans

APPEA Code of Environmental Practice

The Code of environmental practice (Department of Primary Industries and Fisheries, 2008) objectives include “To reduce the risk of introduction (or spread) of weeds, pests and pathogens to as low as reasonably practical and to an acceptable level.”

Performance targets suggested by the code of practice include being able to demonstrate that:

- there were no weeds, pests and pathogens introduced (or spread)
- appropriate weed and pest management measures were implemented in accordance with legislative requirements and agreed procedures
- appropriate monitoring programs were conducted to enable introductions to be identified, and the results communicated in accordance with agreed procedures
- any weeds, pests and pathogens detected were appropriately dealt with

- where relevant, dieback mitigation procedures were implemented and strictly adhered to.

Petroleum Industry – Pest Spread Minimisation Advisory Guide (June 2008)

This advisory guideline was developed in consultation with various stakeholders including:

- Biosecurity Queensland, Department of Primary Industries and Fisheries (DPI&F)
- Local government
- Industry representatives
- Queensland Murray Darling Committee
- Australian Petroleum Production and Exploration Association (APPEA).

The guideline provides a framework for introducing the following:

1) Managing pest spread
2) Managing pest infestations
3) Reviewing and monitoring effectiveness of actions

5.2.2 New South Wales

The Noxious Weeds Act 1993

The Noxious Weeds Act 1993 (NW Act) is the primary weed legislation in New South Wales (NSW). The NW Act allows for the declaration of serious weeds that could spread to other areas and within an area and cause harm to the community. Additionally the weed must be controlled through reasonable measures. Table 7 provides an overview of the NSW noxious weeds classes and the control requirements.

Table 7: Control Classes of noxious weeds from the Noxious Weeds Act (Source: NSW Government Department of Primary Industries and Agriculture, undated)

Control Class	Weed type	Example control requirements
Class 1	State prohibited weeds. Plants that pose a potentially serious threat to primary production or the environment and are not present in the State or are present only to a limited extent.	Class 1 and 2 weeds: ▪ must be eradicated from the land and the land must be kept free of the plant. ▪ are "notifiable" and a range of restrictions on their sale and movement exist. ▪ Prohibited from sale.
Class 2	Regionally prohibited weeds. Plants that pose a potentially serious threat to primary production or the environment of a region to which the order applies and are not present in the region or are present only to a limited extent. Class 2 weeds are notifiable under the NW Act.	
Class 3	Regionally controlled weeds. Plants that pose a potentially serious threat to primary production or the environment of a region to which the order applies, are not widely distributed in the area and are likely to spread in the area or to another area.	The plant must be fully and continuously suppressed and destroyed and in some cases the plant may not be sold, propagated or knowingly distributed.

Control Class	Weed type	Example control requirements
Class 4	Locally controlled weeds. Plants that pose a potentially serious threat to primary production, the environment or human health, are widely distributed in an area to which the order applies and are likely to spread in the area or to another area.	The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction.
Class 5	Restricted weeds. Plants that are likely, by their sale or the sale of their seeds or movement within the State or an area of the State, to spread in the State or outside the State.	There are no requirements to control existing plants of Class 5 weeds. However, the weeds are "notifiable" and a range of restrictions on their sale and movement exists. Class 5 weeds are prohibited from sale.

New South Wales - Rural Lands Protection Act 1998

Under the NSW *Rural Lands Protection Act 1998* (RLP Act), landholders have an obligation to eradicate pest animals on land they own, occupy or manage. Current species declared as pests in New South Wales include; rabbits, feral pigs, wild dogs and a number of locust species. Foxes and mice are presently classed as nuisance animals in NSW and there is no obligation for landholders to control these. Many local councils and state government land management agencies however undertake fox control programs.

New South Wales - Biodiversity Strategy

The NSW Biodiversity Strategy 2010-2015 is currently in draft. The Biodiversity Strategy includes:

“continued focus on existing programs such as reserve expansion and management, invasive pest and weed control and a range of programs underway to ensure the health and sustainability of our rivers and wetlands”

Pests in NSW are managed in line with the threat to biodiversity and the key threatening processes. The draft Biodiversity Strategy Reports that:

“Thirty-four specific Key Threatening Processes have been identified as posing a threat to threatened species, populations or ecological communities under the TSC Act. Threat abatement plans have been prepared for three Key Threatening Processes: the invasion of native plant communities by Hrysanthemoides monilifera *(bitou bush and boneseed), predation by the red fox (*Vulpes vulpes*), and predation by* Gambusia holbrooki*, the plague minnow.”*
(NSW Department of Environment, Climate Change and Water and Industry and Investment, 2010).

New South Wales - Invasive Species Plan

The NSW Invasive Species Plan 2008-2015 is an eight year plan to improve the management of invasive species.

Four goals are identified to deal with challenges faced by invasive species (NSW Department of Primary Industries, 2008):

1. *Exclude* – prevent the establishment of new invasive species
2. *Eradicate or contain* – eliminate, or prevent the spread of new invasive species
3. *Effectively manage* – reduce the impacts of widespread invasive species
4. *Capacity building* – ensure NSW has the ability and commitment to manage invasive species

5.3 Local Government Obligations and Strategies

Queensland Local Government – Pest Management Plans

Local Governments are required to develop, adopt and implement a Pest Management Plan under the LP Act. The Pest Management Plans are intended to provide an integrated planning framework for the management of pest animals and plants across Queensland. The LP Act sets out desired outcomes for local government pest management plans that align with the state animal and weed pest strategies.

Arrow operations cover 30 local government areas in Queensland, with some of these already having Pest Management Plans in place that are endorsed by Council and approved by the Minister. Following amalgamation of councils in Queensland, many of the Local Government Pest Management Plans need updating and compilation. A summary of the councils Pest Management Plan status and topical information contained in plans is included in Appendix B, including a summary of pest management plans obtained at the time of developing this Program.

Queensland Local Law Declared Pests

Local governments have the power to declare pest species under local laws, where they have not been declared under the Land Protection Act. The local law declaration allows for enforcement of the control of the identified pests. A list of locally declared pest species is also included in Appendix B.

6.0 DESIRED OUTCOMES AND STRATEGIC OBJECTIVES FOR PEST MANAGEMENT

Strategic objectives for pest management across Arrow Energy operations have been determined based on legislative requirements, internal discussions and best practice information and guidance from strategy documents. Strategic actions align to the objectives to provide a framework for identifying and implementing management actions. The Arrow Energy Pest Management Action Plan (Appendix C) details the management actions to address the strategic objectives and desired outcomes identified in Table 8:

Table 8: Desired Outcomes and Strategic Objectives for Pest Management across Arrow Energy Operations

Desired Outcome 1	Strategic Objectives
Pests are effectively managed at Arrow sites and prevented from spreading to and impacting on new areas.	Protocols are established to minimise the risk of movement and spread of weeds and disease
	Infestations are detected and recorded through a surveillance and mapping program
	Infestations are effectively managed at all Arrow controlled sites
Desired Outcome 2	**Strategic Objectives**
Build capacity within Arrow Energy of pests and their management.	Raise awareness with staff and contractors to support and undertake pest management
	Enhance Arrow's capacity and commitment towards pest management
	Monitoring will be used as a effective management tool
Desired Outcome 3	**Strategic Objectives**
Effective pest management is based on a shared responsibility.	Best practice pest management is developed and adopted by Arrow Energy
	Pest management requires coordination across all stakeholders in the community, regardless of tenure
	Coordinate and manage implementation of the program

7.0 CURRENT ARROW IDENTIFICATION OF POTENTIAL PEST SPECIES

Arrow, in recognising its environmental obligations with regard to pest management, aims to identify pest species as being plants and animals being classified (declaration) under State legislation. Reference to Queensland – *Environment Protection Act* (1994), *The Land Protection (Pest and Stock Route Management) Act* (2002), Local Government – Local By-laws, Declared Pests. For New South Wales – *The Noxious Weeds Act* 1993 and *NSW Rural Lands Protection Act* 1998.

Arrow also undertakes ecological assessments to determine the presence of weeds* and animals involving desktop and field assessments by experienced ecologists and utilising a combination of information sources, focussing on existing baseline data from Arrow Surveys.

Field assessments are currently conducted to compile baseline information on sites where infrastructure will be located. Preconstruction weed inspections are used to determine the presence of weeds and determine the ongoing monitoring and management schedules. Additional project specific field surveys are conducted for large scale projects such as the proposed LNG plant in Gladstone (Ecosure, 2011).

*plant species recognised with weedy characteristics – invasive qualities, long seed life, high reproduction/breeding systems, highly adaptable, shade tolerant

8.0 PEST FLORA

8.1 Species identified

Arrow occupies a large geographic area of Queensland and part of northern NSW (Appendix A). The production areas are currently located around the towns of Dalby and Moranbah. Exploration activities are conducted in a much larger area, encompassing the Darling Downs; the Brigalow belt (southern and northern); coastal areas around Rockhampton, Mackay and Townsville; Brisbane valley; Calliope; Emerald, Baralaba; and Northern New South Wales. Arrow controlled sites may be located within the broad area that is managed by 38 regional councils. Where information is available, the species identified by each regional council as high priority pest plant and pest animal species are listed in Appendix B. This information is used in conjunction with historical site data and information gathered from the consultation process to identify the pest species that are likely to occur on or adjacent to Arrow controlled sites.

8.2 Specific Pest Plants Identified

Different pest plant species require specific controls to ensure they are managed appropriately. Table provides an overview of the key declared pest plants identified by Arrow as priority for management as a result of being potentially highly invasive and spread through contaminated vehicles and machinery. Where pest species have been identified as a priority (related to frequency), species specific guidelines have been developed that detail the minimum environmental standards required for management. A full list of relevant weed species for Arrow Energy operations based on consultation and Local Government Pest Management Plans is included in Appendix B and should be referred to for more information.

Table 9: Priority Pest Plants

Priority Pest Plant	Status on Arrow Sites	Declaration Status
Parthenium *(Parthenium hysterophorus)*	Parthenium is reported extensively across the tenements that Arrow operates on in Queensland. It is also identified by many of the local government authorities as a problem weed in the shire or region in the Arrow tenements.	Parthenium is a Class 2 declared weed in Queensland, a Class 1 in all of NSW under the *Noxious Weeds Act 1993* and listed as a WoNS.
Weedy Sporobolus Grasses (WSG) Giant Rats Tail Grass (*Sporobolus pyramidalis and S. natalensis*), Giant Parramatta Grass (*S,africanus, S.fertilis*) American Rats Tail Grass (*S. jacquemontii)*	Giant Rats Tail Grass is found across some of the tenements that Arrow operates on in Queensland and Northern NSW. It is also identified by many of the local government authorities as a problem weed in the shire or region in the Arrow tenements.	In Queensland, Weedy Sporobolus grasses are a declared Class 2 declared weed. in Queensland and a Class 3 In New South Wales, WSG have been declared noxious in some areas. Giant rat's tail grass (*S. pyramidalis* and *S. natalensis*) is considered a Class 3 weed in areas where it is found, and must by law be fully and continuously suppressed and destroyed. Giant Parramatta grass (*S. fertilis*) has been declared in some areas as a Class 3 pest and in others as a Class 4 pest.
Chilean Needle Grass *(Nassella neesiana)*	Chilean Needle Grass has not been reported across some of the tenements that Arrow operates on in Queensland. The plant has been identified by many of the local government authorities as a problem weed in shires or regions in the Arrow tenements.	Chilean Needle Grass is a Class 2 declared weed in Queensland and declared as a Class 3, 4 in NSW under the *Noxious Weeds Act 1993* and listed as a WoNS.
Harrisia cactus, (*Eriocereus* spp.)	Harrisia cactus is found across some of the tenements that Arrow operates on in Queensland. It is also identified by many of the local government authorities as a problem weed in the shire or region in the Arrow tenements.	All species of Harrisia Cactus (*Harrisia* spp. syn. *Eriocereus* spp.) are Class 1 declared plants except for *H. martinii*, *H. tortuosa* and *H. pomanensis* syn. *Cereus pomanensis* which are Class 2 declared pest plants under Queensland legislation. Harrisia species are declared Class 4 weeds in all of NSW.

Priority Pest Plant	Status on Arrow Sites	Declaration Status
Fireweed (*Senecio Madagascariensis)*	Fireweed has been found across some of the tenements that Arrow operates on in Queensland. It is also identified by many of the local government authorities as a problem weed in some shires or regions in the Arrow tenements.	Fireweed is a Class 2 declared weed in Queensland and declared as a Class 4 in NSW under the *Noxious Weeds Act 1993* and listed as a WoNS.
Prickly Pear *(Opuntia spp.)*	Prickly Pear is reported extensively across the tenements that Arrow operates on in Queensland. It is also identified by many of the local government authorities as a problem weed in the shire or region in the Arrow tenements.	Prickly Pear is a Class 1 declared weed in Queensland and a Class 4 in all of NSW under *Noxious Weeds Act 1993.*
Mother of Millions (*Bryophyllum spp.*)	Mother of Millions is found across some of the tenements that Arrow operates on in Queensland. It is also identified by many of the local government authorities as a problem weed in some shires or regions in the Arrow tenements.	Mother of Millions is a Class 2 declared weed in Queensland and declared as a Class 3, 4 in NSW under the *Noxious Weeds Act 1993.*
Bellyache Bush (*Jatropha gossypiifolia)*	Bellyache Bush is found across some of the tenements that Arrow operates on in Queensland. It is also identified by many of the local government authorities as a problem weed in some shires or regions in the Arrow tenements.	Bellyache bush is a Class 2 declared weed in Queensland and listed as a WoNS.
Prickly Acacia *(Acacia nilotica)*	Prickly acacia has not been reported across some of the tenements that Arrow operates on in Queensland. The plant has been identified by many of the local government authorities as a problem weed in shires or regions in the Arrow tenements.	Prickly acacia is a Class 2 declared weed in Queensland and declared as a Class 1 in NSW under the *Noxious Weeds Act 1993* and listed as a WoNS.
Parkinsonia (*Parkinsonia aculeata)*	Parkinsonia is found across some of the tenements that Arrow operates on in Queensland. It is also identified by many of the local government authorities as a problem weed in some shires or regions in the Arrow tenements.	Parkinsonia is a Class 2 declared weed in Queensland and as a Class 1 in NSW under the *Noxious Weeds Act 1993* and listed as a WoNS.and listed as a WoNS.
Chinee Apple *(Ziziphus mauritiana)*	Chinee Apple is found across some of the tenements that Arrow operates on in Queensland. It is also identified by many of the local government authorities as a problem weed in the shire or region in the Arrow tenements.	Chinee apple is a Class 2 declared weed in Queensland.

9.0 PEST FAUNA

9.1 Species identified

The species identified by each regional council as a high priority pest animal species, where the information was available, is listed in Appendix B.

9.2 Specific Pest Animals Identified

As for pest plants there are legislative obligations for the management of some animal species. Table provides an overview of priority pest animals their requirements and expectations for managing pest animals.

Table 10: Priority Pest Animals

Priority Pest Animals	Status on Arrow Sites	Declaration Status
Rabbits (*Oryctolagus cuniculus*)	Rabbits were reported to be present at numerous Arrow controlled sites and are declared under local government authorities in the areas where Arrow operates.	Rabbits are Class 2 declared pests under Queensland legislation and are declared under the Rural Lands Protection Act 1998 (the RLP Act) in NSW
Wild Dog (*Canis lupus*)	Wild dogs have been observed at Arrow controlled sites and are listed by relevant local government authorities in the locations where Arrow conducts its operations	Wild dogs are declared pests (Class 2) under Queensland legislation and are declared under the Rural Lands Protection Act 1998 (the RLP Act) in NSW
Feral pigs (*Sus scrofa*)	Feral pigs have been observed at Arrow sites and are listed by relevant local government authorities in the locations where Arrow conducts its operations.	Feral pigs are declared pests (Class 2) under Queensland legislation and are declared under the Rural Lands Protection Act 1998 (the RLP Act) in NSW
Cat *(Felis catus)*	Feral cats have been observed at Arrow processing sites and are listed by relevant local government authorities in the locations where Arrow conducts its operations.	Feral cats are declared pests (Class 2) under Queensland legislation.
Fire ants *(Solenopsis invicta)*	Fire ants were not reported to be present, at Arrow controlled sites during the consultation process, however they have been identified and managed as a risk from imported materials. They are currently found in areas of South East Queensland.	Fire ants are declared under local government authorities in the areas where Arrow operates. Fire ants are a notifiable pest under Queensland legislation.

Priority Pest Animals	Status on Arrow Sites	Declaration Status
Deer (*Family Cervidae*)	Deer are observed at various Arrow controlled sites and are reported by numerous councils as pests in the areas where Arrow operates.	All feral deer (i.e. deer not contained in a deer proof enclosure) are declared under Queensland legislation. Class 1 Deer include: ▪ feral hog deer (*Axis porcinus*) ▪ feral sambar deer (*Cervus unicolor*) ▪ feral white-tail deer (*Odocoileus virginianus*). Class 2 deer include: ▪ feral rusa deer (*Cervus timorensis*) ▪ feral chital (axis) deer (*Axis axis*). Class 3 deer include: ▪ feral red deer (*Cervus elaphus*) ▪ feral fallow deer (*Dama dama*)
Migratory locust (*Locusta migratoria*) and Spur throated locust (*Austracris guttulosa)*	Locusts were reported to be present, at times, at a few Arrow controlled sites during the consultation process and are declared under local government authorities in the areas where Arrow operates.	Various locust species are Class 2 declared pests under Queensland legislation. Locusts are declared under the Rural Lands Protection Act 1998 (the RLP Act) in NSW
Cane toads (*Bufo marinus)*	Cane toads are frequently observed on Arrow controlled sites.	They are not a declared pest and are only noted by one local government authority (Gladstone Regional Council) in the areas that Arrow Operate.
Yellow crazy ants *(Anoplolepis gracilipes)*	Yellow crazy ants, also known as crazy ants are an introduced exotic species and were not reported to be present at Arrow controlled sites during the consultation process,	The yellow crazy ant is a Class 1 declared species in Queensland. Class 1 pests established in Queensland are subject to eradication from the state. It is also an offence to release a Class 1 animal into the environment.

10.0 PATHOGENS

10.1 Specific pathogens identified - Myrtle rust

Pathogens on Arrow controlled sites were not reported and were not raised in Local Government Pest Management Plans, apart from the recently identified pathogen, Myrtle Rust. Table provides a summary of the pathogen Myrtle Rust, its status on Arrow sites and potential impact.

Table 11: Specific Pathogen Descriptions and Status on Arrow Sites

Status on Arrow Sites	Description and Impacts
Myrtle rust	
Myrtle rust has only recently been identified and has not yet been identified on Arrow sites. Myrtle Rust is a serious fungal disease that affects plants in the Myrtaceae family, such as rose apple (lilly pilly), tea tree and bottle brush. Because it is a new disease to Australia, its full range we don't know. It is now widely spread in South East Queensland but recent detections have been confirmed in nurseries in Cairns and Townsville.	Myrtle rust cannot be eradicated and will continue to spread because it produces thousands of spores that are easily transported by wind, human activity and animals. Myrtle rust can also be spread on plant material and cuttings, on the wind, and through contact with people and animals. Myrtle rust may naturally spread to a property as the disease progresses.

11.0 SUMMARY AND CONCLUSIONS

This Program supports Arrow in upholding its environmental obligations in regard to pest management. This Program provides Arrow with a strategic and useable document to guide the management of pest flora and fauna as relevant to its operations, by:

- identifying the objectives for pest management planning consistent with national, state and local pest management requirements
- identifying actions to be implemented by Arrow that are consistent with various planning strategies
- providing strategic direction in relation to pest management for Arrow as its operations expand
- providing a framework for best practice pest management for Arrow Energy.

The Program will continue to evolve over time, with the content of the Action Plan and Appendices in particular requiring regular update and review.

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APPENDIX A

Arrow Energy Tenements

APPENDIX B

Local Government Area Pest Management Plan Summaries
Pest Flora Matrix (including LGA high priority)
Pest Weed Matrix (including LGA high priority)

APPENDIX C

Arrow Energy Pest Management - Action Plan

Appendix B. Species information sheets

Fact sheet

DECLARED CLASS 3 PEST PLANT

Basket asparagus fern

Ground asparagus fern

Asparagus aethiopicus cv. Sprengeri

Basket asparagus is one of the most significant garden escapees invading the coastline. It survives well on sand dunes, shallow-soiled headlands and in rainforest understory. In some places it has become the dominant ground cover displacing native plants, even in undisturbed systems. Introduced from Africa, it is a problem along the entire coast and is also known as ground asparagus or asparagus fern. It has been recognised in Australia as a Weed of National Significance (WoNS).

Declaration details

Basket or ground asparagus fern is a declared Class 3 plant under the *Land Protection (Pest and Stock Route Management) Act 2002*. The Act prohibits the supply or sale of Class 3 plants and may require their removal from environmentally significant areas.

PP66 June 2012

Queensland Government

Description and general information

Basket asparagus has long, arching, prickly stems up to 2 m long. The slender leaves are light green. It produces clusters of small, cream-coloured flowers (normally August to September) and fruits (normally September to October) up to 8 mm in diameter. Fruits ripen to bright red and each contains a single, black, round seed. Tubers bearing starch and water are present, but these do not regrow or reproduce.

Control

Physical

This plant need not be a problem if it is kept in a pot or hanging basket in a location that can not be accessed by birds. Birds that eat the berries disperse this plant. Unwanted plants should be dug out and disposed of at the appropriate council landfill site. Take care to remove the entire crown or underground stem of the plant to reduce the chance of regrowth.

Herbicide

The herbicides listed in the table below are permitted to be used in the listed situations. Before using any herbicide always read the label carefully. All herbicides must be applied strictly in accordance with the directions on the label and the conditions in the APVMA permit.

Table 1 Herbicides permitted under APVMA PER11463 for the control of basket or ground asparagus fern

Situation	Herbicide	Rate	Comments
Non-agricultural areas, bushland, forests, wetlands, coastal and adjacent areas (Permit PER11463)	metsulfuron-methyl (600 g/L)	10 g per 100 L water plus wetting agent or 100 g/ha plus wetting agent	Spot spray Do not use on coastal dunes or near the root zone of casuarinas or pandanus trees.
	Diesel	Apply neat	Paint or spot spray crowns. Trials suggest spraying the entire central crown to the point of run-off. This does not require cutting or disturbing the target plant or other surrounding vegetation.
	dicamba (500 g/L)	200 mL on mature per 100 L water, up to 1 L on regrowth per 100 L water, or 2 L/ha	Spot spray only for short-term knockdown.

Read the label carefully before use and always use the herbicide in accordance with the directions on the label.

Persons who wish to prepare for use and/or use products for the purposes specified in APVMA permit PER11463 must read, or have read to them, the details and conditions of the permit. APVMA permit PER11463 expires on 30 June 2014 and is available from the APVMA website at www.apvma.gov.au

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

CS1466 5/12

Fact sheet

DECLARED CLASS 2 PEST PLANT

Chinee apple

Indian jujube

Ziziphus mauritiana

Dense infestations of chinee apple (or Indian jujube) create impenetrable thickets that seriously hamper stock management and reduce pasture production and accessibility. Mature trees produce large quantities of fruit that are readily eaten by stock, feral pigs, wallabies and birds, which assists the spread of the seed. Damage to top parts of the plant usually ensures regrowth from lignotubers or cut roots.

Declaration details

Chinee apple weed is a declared Class 2 plant under *Land Protection (Pest and Stock Route Management) Act 2002*. Declaration requires landholders to control declared pests on the land and waters under their control. A local government may serve a notice upon a landholder requiring control of declared pests.

Queensland Government

PP26 June 2011

Description and general information

Chinee apple is a large shrub or small spreading tree up to 8 m high and 10 m in canopy diameter. The plants are densely branched, from ground level in some cases. Stands of chinee apple grow as open forests or form thorny thickets along waterways. Branches are zig-zag in shape and have a leaf and a thorn at each angle.

Leaves are rounded, glossy green on top and almost white underneath, and grow on alternate sides of the branches. Flowers are small and inconspicuous, greenish-white and emit an unpleasant smell. The edible fruits are similar in size and structure to a cherry, but pale yellow or orange when ripe.

Habitat and distribution

Chinee apple is native to southern Asia and eastern Africa. It was first recorded in the Torres Straits in 1863 and in Townsville in 1916.

The species is widespread in north Queensland, mainly in the areas surrounding towns associated with mining early this century. The largest areas of dense chinee apple are around Charters Towers, Mingela, Ravenswood and Hughenden, but the plant also occurs around many other towns in the drier parts of north and central Queensland.

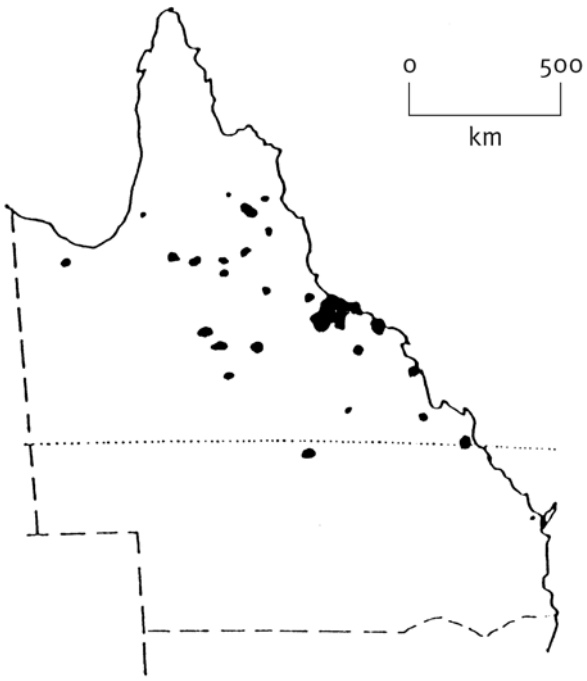
Chinee apple is restricted to the drier tropics with an annual rainfall of less than 1–200 mm. It also grows in areas with an annual rainfall as high as 470 mm. During the dry season, the plant drops most of its leaves in response to water stress but rapidly produces new leaves with the opening rains of the wet season. Although the species does have a tendency to spread along watercourses in the drier regions, it is also capable of growing into dense stands on dry, exposed hillsides.

Chinee apple occurs in a wide range of soil types in association with different vegetation groups. It has successfully established on coarse-textured, gravelly mullock heaps; deep coarse-textured sands; deep alluvial soils; shallow-surfaced solodic soils; and cracking clay soils. The pattern of spread away from the towns has shown no marked preference for any soil type or vegetation association.

The major factor that appears to affect the growth of chinee apple is the density of the associated vegetation. Chinee apple does not establish successfully under the canopy of other trees and the species is normally restricted to areas that have sparse tree cover or where the other tree vegetation has been removed.

The old mining centres provided ideal conditions for establishment of chinee apple with the complete removal of all trees for pit timber and fuel. Chinee apple is now virtually the only tree species growing for several kilometres around these centres.

Figure 1 Distribution of chinee apple



Control

Effective control of chinee apple can be achieved through a combination of mechanical and herbicide treatments, or by herbicide treatment alone. All areas treated must be periodically checked and any regrowth treated or the initial treatment efforts will be wasted. Follow-up is esential to ensure a successful control program.

Mechanical control

Dense infestations can be initially cleared by stick raking, ripping or using a cutter bar (if the terrain and soil type permit). Remaining broken and exposed stems should be treated by basal bark spraying as soon as possible following clearing.

In order to ensure a successful control program, regrowth must be sprayed.

Cultivation and planting crops or improved pasture will assist in the prevention of re-infestation. Herbicide treatment of regrowth should still be carried out and maintained so the initial program is not wasted.

Fire will cause some damage to the plant but regrowth is normally rapid and few plants are killed. Seedlings may be more susceptible to fire but the survival of mature plants will maintain the existing problem.

Herbicide control

The methods of chemically treating chinee apple are described below. The herbicides registered for these methods are listed in Table 1.

Basal bark spray

For stems up to 15 cm in diameter, carefully spray completely around the base of the plant to a height of 40 cm above ground level. It is important to thoroughly spray into the crevices of multi-stemmed plants. Larger trees may be controlled by spraying to a greater height, up to 100 cm above ground level. The best time for treatment is during autumn when plants are actively growing and soil moisture is good.

Cut stump treatment

At any time of year, cut the stems off horizontally as close to the ground as possible and immediately (within 15 seconds) swab or spray the cut surfaces and associated stem with the herbicide mixture.

Soil application

Apply granules over an area extending from the main stem to 30 cm outside the canopy drip line to cover the main part of the root system. Treated plants will not be affected until sufficient rainfall moves the herbicide into the root zone. Do not use residual herbicides within a distance of twice the height of desirable trees.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

Table 1 Herbicides registered for the control of chinee apple

Situation	Herbicide	Rate	Optimum stage and time	Comments
Basal bark/ cut stump	Triclopyr and picloram e.g. Access®	1 L/60 L diesel	Basal bark spray when actively growing Cut stump any time of year	Thoroughly spray all crevices. Basal bark spray plants with up to 15 cm basal diameter. Cut stump plants with greater than 15 cm basal diameter. For cut stump, spray immediately after cutting.
	Fluroxypyr e.g. Starane 200®	3 L/100 L diesel		Spray plants with up to 15 cm basal diameter. For cut stump, spray immediately after cutting.
	Fluroxypyr e.g. Tomigan 200EC®	3 L/100 L diesel		
	Triclopyr e.g. Garlon 600®	1 L/60 L diesel	Basal bark spray when actively growing Cut stump any time of year	Thoroughly spray all crevices. For cut stump, spray immediately after cutting.
	Triclopyr e.g. Invader 600®	1 L/60 L diesel		Basal bark spray suckers and seedlings with up to 5 cm basal diameter. Cut stump suckers or seedlings with greater than 5 cm basal diameter. Spray immediately after cutting.
	Triclopyr e.g. Hurricane 600®	1 L/60 L diesel		
	Triclopyr e.g. Redeem 600®	1 L/60 L diesel		Basal bark spray plants with up to 5 cm basal diameter.
	Triclopyr e.g. Triclon®	1 L/60 L diesel		Basal bark spray plants with up to 5 cm basal diameter. Cut stump plants with greater than 5 cm basal diameter. Spray immediately after cutting.
	Triclopyr e.g. Tryclops®	1 L/60 L diesel		
	Triclopyr e.g. Safari 600EC®	1 L/60 L diesel		
Basal bark spray only	2,4-D e.g. AF Rubber Vine Spray®	1 L/10 L diesel	When actively growing	Basal bark spray plants with up to 5 cm basal diameter.
High volume spray	Triclopyr and picloram e.g. Grazon DS®	0.35 L/100 L water	Seedling regrowth to 2 m Spray when plants are actively growing	A wetting agent is recommended to increase effectiveness.
Soil application	Picloram-triethanolamine e.g. Tordon® granules	35–45 g/m^2	Apply prior to expected rain	Refer to label for critical comments.

CS0472 06/11

Giant rat's tail grass

and other weedy *Sporobolus* species

Sporobolus pyramidalis, S. natalensis, S. jacquemontii, S. fertilis and *S. africanus*

Weedy *Sporobolus* can out-compete desirable pasture grasses

One seed head of giant rat's tail grass can produce up to 85 000 seeds per year with initial seed viability of about 90%

Giant rat's tail grass and other weedy *Sporobolus* grasses are invasive grasses that can reduce pasture productivity, out-compete desirable pasture grasses and cause significant degradation of natural areas.

These species were originally introduced as contaminants in pasture seed and have now adapted well to large areas of eastern Australia.

Five species of introduced *Sporobolus* grasses are declared Class 2 plants in Queensland:

- giant rat's tail grass *(S. pyramidalis and S. natalensis*)
- American rat's tail grass *(S. jacquemontii)*
- giant Parramatta grass *(S. fertilis)*
- Parramatta grass *(S. africanus)*.

Declaration details

Under Queensland's *Land Protection (Pest and Stock Route Management) Act 2002*, landholders are required to control Class 2 declared pests on land and waters under their control. Local governments may serve notices to landholders requiring control of declared pests.

Description and general information

Weedy *Sporobolus* grasses are robust, tufted, perennial grasses growing up to 2 m tall. They are difficult to distinguish from other pasture grasses before maturity. However, their leaves are noticeably tougher than those of any other species.

They can also be difficult to distinguish from native *Sporobolus* grasses; however, the native grasses tend to be shorter and softer and have less dense seed heads than giant rat's tail grass. The seeds of all species are indistinguishable in pasture seed samples using current identification techniques.

Weedy *Sporobolus* seeds are spread:

- by livestock (up to 30 000 viable seeds/beast/day) in manure and on fur and hooves
- by feral and native animals
- on vehicles and machinery (especially slashers and earthmoving equipment)
- in hay and untested pasture seed

by fast-flowing water over turf.

Queensland Government

PP48 April 2012

Giant rat's tail grass

Giant rat's tail grass grows to 0.6–1.7 m tall, with a seed head of up to 45 cm long and 3 cm wide. Seed head shape changes from a 'rat's tail' when young to an elongated pyramid shape at maturity. Unlike Parramatta grass and giant Parramatta grass, giant rat's tail grass does not develop 'sooty spike' on its seed heads.

Distribution of *S. natalensis*—Rockhampton (Queensland) to Port Macquarie (New South Wales).

Distribution of *S. pyramidalis*—Cooktown (Queensland) to Central Coast (New South Wales).

American rat's tail grass

American rat's tail grass grows to 50–75 cm tall, with a seed head of up to 25 cm long and 0.5–3 cm wide.

Distribution—Cape York (Queensland and Northern Territory) to South East Queensland.

Giant Parramatta grass

Giant Parramatta grass grows to 0.8–1.6 m tall, with a seed head of up to 50 cm long and 1–2 cm wide. The branches of the seed head are pressed against the axis and overlap, although lower ones generally spread at maturity.

Distribution—Mossman (Queensland) to Central Coast (New South Wales).

Parramatta grass

Parramatta grass grows to 0.15–1.1 m tall, with a seed head of up to 50 cm long and 1–2 cm wide. The leaves of mature plants are slender and erect, 6–18 cm long. Parramatta grass is not as invasive as giant Parramatta grass.

Distribution—Brisbane (Queensland) to Adelaide (South Australia).

Potential damage

Weedy *Sporobolus* grasses:

- have low palatability when mature
- are difficult to control
- can quickly dominate a pasture, especially following overgrazing or soil disturbance
- can affect cattle health and productivity (including finishing times, weaning percentages and weights)
- can set seed throughout frost-free periods (with a significant proportion of seed remaining viable for up to 10 years)
- can become a serious fire hazard in spring months.

Habitat and distribution

Giant rat's tail grass has adapted to a wide range of soils and conditions.

Ecoclimatic modelling suggests giant rat's tail grass is suited to conditions present in 30% of Australia (223 million ha) and 60% of Queensland (108 million ha), including areas receiving as little as 500 mm average annual rainfall.

Control

Prevention

Maintain vigorous, dense pastures and use higher grass seed sowing rates to reduce the chance of invasion and to increase competition against weedy *Sporobolus* seed establishment. Do not expect heavy grazing to control weedy *Sporobolus* grasses—research indicates that grazing may actually favour its spread.

When moving stock from infested areas into clean areas, spell the stock in yards for at least five days. Similarly, spell stock purchased from known or suspected infested areas before releasing them into larger paddocks. Alternatively, quarantine new stock in a densely pastured, well-monitored holding paddock. Move stock when there is no dew or rain, to decrease the amount of seed sticking to their coats (see Table 1).

Establish weed-free buffer strips along boundary or perimeter fences, drainage lines and roadsides to restrict the spread of weedy *Sporobolus* grasses. Always clean machinery thoroughly after working in infested areas. Follow integrated control strategies using herbicides and other control methods, combined with good property hygiene.

Consider the attributes of replacement pasture grasses when deciding what to sow. If possible, choose grasses that are:

- well adapted to local environmental conditions and soil types
- stoloniferous or rhizomatous in growth habit
- resistant to heavy grazing
- palatable and productive
- competitive all year (i.e. do not open up in late winter/spring)
- not inclined to decline as soil fertility decreases
- fast to establish.

If a sown pasture species does not contain most of these attributes, it is unlikely to be successful as part of a weedy *Sporobolus* grass control program.

Some pasture species, while providing strong competition once established, are weak competitors with weedy *Sporobolus* grasses in their early stages of establishment (e.g. Koronivia grass and Bisset creeping blue grass). These grasses are most successful against weedy *Sporobolus* when sown with other grasses that are vigorous when young and provide early competition against weedy *Sporobolus* grasses (e.g. Rhodes grass). See *Weedy Sporobolus grasses: best practice manual* (Queensland Department of Primary Industries, revised edition 2007) for further information about pasture species that can be used in particular situations.

Suppliers must not supply anything containing reproductive material of a plant that is a Class 1 or Class 2 pest under the Land Protection (Pest and Stock Route Management) Regulation 2003.

Management strategies

Always commence control programs in areas of light infestation, and work towards the denser infestations.

If, after considering the management options set out below, you choose to use a herbicide option, ensure you apply all herbicides strictly according to the directions on the label and the directions of any Australian Pesticides and Veterinary Medicines Authority (APVMA) permit. You **must** read APVMA permit 9792 if you wish to prepare or use products for the control of *Sporobolus* weeds in situations other than those specified on the product label.

Some herbicides permitted or registered for giant rat's tail grass control have withholding periods and significant ongoing management requirements in grazing and dairy farming. If you have or may have dairy or beef cattle on your property at any stage in the future, carefully consider these requirements when choosing herbicides for use on your property.

Some details of management options are provided below.

Scattered plants and light infestations

Choose **one** of the following options:

(a) Spot spray with glyphosate.

(b) Spot spray with flupropanate.

(c) Use glyphosate through a pressurised wick wiper.

(d) Hand chip, bag and remove stools from the paddock and burn them.

Dense infestations on arable land

(a) Cropping option

First summer (early)

1. Boom spray with glyphosate as per label or permit directions and burn prior to ploughing.
2. Spot spray or hand chip fence lines, headlands, drainage lines, shelter belts etc. for weedy *Sporobolus* grasses missed in cultivation. Plant a long-season forage sorghum variety using a recommended pre-emergent herbicide.
3. Spot spray or hand chip any surviving weedy *Sporobolus* grasses to prevent reseeding.

Second summer

1. Boom spray with glyphosate to control new seedlings and crop regrowth prior to cultivation.
2. Follow the same procedures and similar cropping as for the first summer.

Third summer

1. Boom spray with glyphosate to control crop regrowth and any weedy *Sporobolus* seedlings.
2. Plant paddocks with improved pastures using minimum tillage techniques to restrict bringing buried seed to the surface. Use a direct drill planter or surface broadcasting and rolling techniques. Plant fast-growing pasture grasses at triple the standard sowing rates to compete with weedy *Sporobolus* seedlings.
3. Fertilise the pasture for fast pasture establishment.
4. Spot spray or hand chip weedy *Sporobolus* seedlings.

(b) Pressurised wick wiper option

To be effective, this option requires three treatments over an 18-month period.

First treatment (midsummer)

1. Make sure there is a 30 cm height difference between weedy *Sporobolus* and other pasture plants by selective grazing of the 'good' pasture.
2. Wick wipe weedy *Sporobolus* grass using glyphosate as per label or permit directions.
3. Graze using increased stocking rates after wick wiping.

Second treatment (late summer or autumn)

Wick wipe weedy *Sporobolus* grass using glyphosate as per label or permit directions.

Third treatment (next summer)

Wick wipe weedy *Sporobolus* grass using glyphosate as per label or permit directions.

Dense infestations on non-arable land

Choose **one** of the following options:

(a) In summer, apply glyphosate through a pressurised wick wiper (if terrain and timber allow).

(b) In summer, boom or blanket spray with glyphosate in split applications as per label or permit directions (see Table 2) and replant the pasture using fast-growing pasture grasses at double the standard sowing rates.

(c) In winter or spring, boom or blanket spray with flupropanate as per label or permit directions.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

Also refer to *Weedy Sporobolus grasses: best practice manual* (Queensland Department of Primary Industries, revised edition 2007).

Table 1. Best practices for management of weedy *Sporobolus* infested paddocks

Dos	Don'ts
Cattle	
• Manage the grazing and stocking rate to maintain good ground cover of pasture. • Muster only in the afternoon when plants and seeds are dry. • Restrict cattle to a small paddock or a laneway (on hay) for five days after grazing the weedy *Sporobolus* paddock. • Muster on foot or on horseback to prevent seed contamination of machinery.	• Don't overgraze, as this will create bare patches that allow weedy *Sporobolus* grass seedlings to emerge. • Don't muster on wet days or when the soil is muddy. • Don't deliberately overstock paddocks infested with weedy *Sporobolus*. • Avoid creating bare ground from trampling around mineral licks etc.
Machinery	
• Provide a specific hose-down tarmac to clean contaminated machinery. • Keep roadways, laneways, stock routes and machinery corridors free of weedy *Sporobolus*.	• Don't slash infested paddocks unless they are part of a wick wiping program. • Don't drive vehicles through infested paddocks.
General hygiene	
• Enclose specimens for identification in tied fertiliser bags.	• Don't drive around the farm with a suspected weedy *Sporobolus* specimen in the cabin or in the back of the ute.
Pasture management	
• Maintain pasture vigour with a maintenance fertiliser program. • Use band seeding if possible, as this is the 'safest' method to plant legumes into an infested pasture. • Plant the recommended competitive pasture grasses.	• Don't allow soil fertility run-down, as this favours weedy *Sporobolus* establishment. • Don't renovate an infested pasture. • Don't burn the pasture unless it is part of a wick wiping, pre-cropping pasture replacement strategy.
Hay and pasture seed	
• Determine the origin of hay and ask for a weed hygiene declaration. • Feed hay in a yard, feedlot or small holding paddock. • Only purchase seed from a reputable seed merchant.	• Don't knowingly purchase hay contaminated with weedy *Sporobolus*. • Don't buy seed without knowing its origin. • Don't buy seed unless it has a weed hygiene declaration. •
Control strategies	
• Choose the best control strategy based on the paddock situation and the weedy *Sporobolus* population before starting the job. • If dairy or beef cattle will be in the paddock at any time in the future, carefully consider the exclusion and withholding requirements of the herbicides and their long-term implications before commencing treatments. • If spot spraying with glyphosate, operate close enough to step on the plant and spray downwards. • Use low-pressure spraying equipment to reduce the risk of overspraying. • Always spot spray the single 'scout' plants around the perimeter of the infestation first, then work inwards.	• Don't spot spray with glyphosate using a high-pressure gun from the cabin of the ute. • Don't wave the spray gun around—if the weedy *Sporobolus* is dense, you should not be spot spraying. • Don't overspray with glyphosate past the point of spray run-off.

The herbicides in Table 2 are permitted under PER9792, which expires on 30 November 2015. You **must** read the permit if you wish to prepare or use products for the control of *Sporobolus* weeds in situations other than those specified on the product label. The permit is available on the APVMA website, www.apvma.gov.au

Table 2. Herbicides permitted for the control of *Sporobolus* weeds

Situation	Application method	Herbicide[1]	Rate	Comments
Pasture, grazed woodlands and agricultural situations prior to sowing; tree and vine crops; lucerne; agricultural non-crop situations	Boom spraying	Glyphosate (360 g/L)	6 L/ha	
Wasteland; forest and conservation areas; margins of aquatic areas; roadsides and easements; rights of way; commercial and industrial areas; public service areas	Boom spraying Double knockdown split application	Glyphosate (360 g/L)	3 L/ha + 3 L/ha	Follow up the first treatment with a later knockdown treatment such as herbicide or tillage.
Pasture, grazed woodlands and agricultural situations prior to sowing; tree and vine crops; lucerne; agricultural non-crop situations	Spot spraying	Glyphosate (360 g/L)	1 L per 100 L water	
Wasteland; forest and conservation areas; margins of aquatic areas; roadsides and easements; rights of way; domestic, commercial and industrial areas; turf; playing fields; golf courses; public service areas; areas surrounding agricultural buildings	Double knockdown split application	Glyphosate (360 g/L)	1 L + 1 L per 100 L water	Follow up the first treatment with a later knockdown treatment such as herbicide or tillage.
	Wick wiping	Glyphosate (360 g/L)	3.3 L per 10 L water	
Pasture; grazed woodlands; agricultural non-crop situations Wasteland; forest and conservation areas; roadsides and easements; rights of way; commercial and industrial areas	Boom spraying	Flupropanate (745 g/L)	1.5–2 L/ha	**Do not** use in channels, drains or watercourses. **Do not** reseed treated areas until at least 100 mm of leaching rain has fallen. **Do not** spray near desirable susceptible trees. **Do not** apply above 3 L/ha to steeply sloping sites. Allow 3–12 months for control, depending on weather conditions and growth stage of plant. High rates will kill native grasses. Apply once per year. Monitor treated areas regularly for any regrowth.
	Suppression of seedlings in improved pasture	Flupropanate (745 g/L)	0.5–2 L/ha	
Pasture; grazed woodlands; agricultural non-crop situations Wasteland; forest and conservation areas; roadsides and easements; rights of way; commercial and industrial areas; golf courses; public service areas; areas surrounding agricultural buildings	Spot spraying	Flupropanate (745 g/L)	200 mL per 100 L water	
	Wick wiping	Flupropanate (745 g/L)	500 mL per 10 L water	

[1] Read APVMA permit PER9792 for rates for products containing glyphosate at 450 g/L or 540 g/L.

Withholding periods

Glyphosate

Not required when used as directed.

Flupropanate

- Broadacre: **Do not** graze or cut for stock feed for at least 4 months after application.
- Spot spray: **Do not** graze or cut for stock feed for at least 14 days after application.
- **Do not** allow stock to graze in treated areas for at least 14 days prior to slaughter.
- **Do not** allow lactating cows or goats to graze in treated areas.

Records

If you graze cattle on more than 2000 ha in the Wet Tropics, Burdekin Dry Tropics or Mackay Whitsunday catchments, you must keep records on the use of flupropanate. See the Reef Wise Farming website, www.reefwisefarming.qld.gov.au

Vendor declarations

If any stock from a flupropanate-treated area are sold, the seller must ensure that details relating to the grazing of stock on the treated land are disclosed in accordance with the obligations outlined on the national vendor declaration relating to that type of livestock. See the Meat & Livestock Australia website, www.mla.com.au, for further details on national vendor declarations.

CS1341 03/12

Fact sheet

DECLARED CLASS 1 AND 2 PEST PLANT

Harrisia cactus

Moonlight cactus

Harrisia martinii, Harrisia tortuosa and *Harrisia pomanensis*

Harrisia cactus can form dense infestations that will reduce pastures to a level unsuitable for stock. Harrisia cactus will choke out other pasture species when left unchecked.

The spines are a problem for stock management, interfering with mustering and stock movement.

Harrisia cactus produces large quantities of seed that is highly viable and easily spread by birds and other animals. As well as reproducing from seed, harrisia cactus has long trailing branches that bend and take root wherever they touch the ground. Any broken-off portions of the plant will take root and grow.

Control of this plant is difficult as it has a deep underground tuberous root system.

Declaration details

Harrisia cactus (*Harrisia martinii*, *Harrisia tortuosa* and *Harrisia pomanensis*) are Class 2 declared pest plants under the *Land Protection (Pest and Stock Route Management) Act 2002*. All other Harrisia species are Class 1 declared pest plants.

Declaration requires landholders to control declared pests on the land and waters under their control. A local government may serve a notice upon a landholder requiring control of declared pests.

Queensland Government

PP22 September 2011

It is an offence to introduce, keep or supply Class 1 or 2 pests without a permit issued by Biosecurity Queensland. Penalties of up to $80 000 apply

Description and general information

Dense infestations of harrisia cactus choke out pasture. The sharp spines, even in light infestations, make pasture unfavourable to stock and interfere with operations such as mustering.

The plant fruits prolifically and seeds are spread widely by birds and animals. Harrisia cactus can also reproduce by stem sections taking root. A deep underground tuberous root system allows the plant to survive even if the above-ground parts are killed.

Harrisia cactus is a perennial. The spiny fleshy stems are jointed and form tangled mats about half a metre high. Many branches often lie flat and take root where they touch the ground. Each section is ribbed lengthwise with six ribs; each rib has low, thick, triangular humps at regular intervals. These humps have cushions of grey felty hairs, three to five short spines lying flat, and one to three erect, stiff, very sharp spines 2.5–3 cm long.

The large flowers open at night. Flowers are pink and funnel-shaped with a tinge of white. These grow singly near the ends of the stems on a scaly but spineless slender grey-green tube 12–15 cm long.

Round, red fruits 4–5 cm across have scattered bumps with hairs and spines. Numerous small black seeds are embedded in the white, juicy pulp of the fruit, which splits open when ripe.

Harrisia cactus roots are of two types. Shallow feeding roots up to 3 cm thick and 30 cm to 2 m long grow mostly horizontally off a crown, up to 15 cm below ground level. Swollen tuberous storage roots descend to a depth of 15–60 cm.

Life cycle

Harrisia cactus bears a bright red fruit containing 400–1000 small black seeds. Fruit and seed are readily eaten by birds and to a lesser extent by feral pigs. Plants are easily established from seed dropped by these animals. Seeds germinate soon after rain.

Seedlings quickly produce a swollen tuberous food storage root that develops as the plant grows. Branches take root where they touch the ground and new plants will grow from broken branches and sections of underground tubers.

Counts of tubers in dense cactus infestations have shown over 125 000 per hectare. Each plant houses many dormant underground buds that are all capable of reshooting when the tip growth dies; any small portion of the tuberous root left in the soil will grow.

Habitat and distribution

Harrisia cactus is a native of Argentina and Paraguay, South America. It was introduced to Australia as a pot plant in the 1890s. In 1935 it was first recognised as a serious pest in the Collinsville district and by the 1950s was rapidly spreading south.

Harrisia cactus is mainly a pest of brigalow and associated softwood country. However, infestations are now appearing in box and ironbark stands and also in pine forests. The cactus is shade tolerant and reaches its maximum development in the shade and shelter of brigalow scrub, though established infestations can persist once scrub is pulled.

Harrisia cactus is found in the Collinsville, Nebo, Moranbah, Dingo, Blackwater and Goondiwindi districts, with minor infestations occurring at Millmerran, Greenmount, Gatton, Ipswich, Rockhampton, Rannes, Mount Morgan, Alpha and Mitchell.

Control

Mechanical control

Dig out plants completely and burn. Ensure that all tubers that can grow are removed and destroyed.

Ploughing is not considered an effective means of control unless followed by annual cropping.

Biological control

Two introduced insects have become established in the field:

- a stem-boring longicorn beetle, *Alcidion cereicola*
- a mealy bug, *Hypogeococcus festerianus*.

The stem-boring beetle only attacks older woody stems. In the Collinsville area, large beetle colonies developed and contributed to the collapse of dense areas of cactus. Populations of *Alcidion cereicola* have declined with the reduction in the cactus in recent years.

The most successful biological control agent is the mealy bug *Hypogeococcus festerianus* which is now present in harrisia cactus in Collinsville, Dingo, Moranbah, Blackwater, Nebo, Charters Towers and Goondiwindi districts, with small colonies established at Alpha, Capella, Rannes, Gatton, Greenmount, Millmerran and Rockhampton.

How mealy bug works

The mealy bug aggregates and feeds in the tips of stems and buds, where it limits growth and causes distortion. This results in the knotting of the stem. The plant's response is to utilise energy reserves within the tuber system to produce new growth. Eventually the plant dies, as it is unable to support the continuous high energy demands.

Dry weather reduces the effectiveness of the mealy bug. When dry, the plant's tuber system becomes dormant. Consequently, mealy bug damage does not result in new growth and the energy reserves within the plant are not affected. Instead the bug may damage all vegetative parts and eventually die out. The tuber will remain dormant until adequate moisture returns, when it will reshoot.

How to spread the bug

Mealy bug disperses naturally via wind, although landholder assistance is necessary for its continuous spread, particularly between patches. The bug is manually spread by cutting infected stems and placing them into healthy plants. The best pieces for starting new colonies are large knobs of twisted and distorted cactus that contain many mealy bugs well protected inside knots. Stem tips covered by white, woolly masses of bug are also good. To collect the bug, cut infected stems approximately 15 cm from the distorted knob and place segments in green, plump sections of the healthy plant. Avoid placing mealy bug in stressed or dried out stems. Small cactus plants require at least one large knot, with larger plants requiring three knots per plant. Where possible, landholders should infest every cactus clump as this ensures a rapid reduction in growth and fruiting potential. When cactus infestations are light, chemical control may be a preferable option.

Cut pieces can be transported in boxes or open vehicles. They are not delicate, but are best kept in the shade. Avoid keeping them in large heaps, in direct sunlight, under tarpaulins or in closed containers for long periods. Such conditions will promote rotting of the stems, leading to poor results or failures. Ideally, stems should be put out within three days and a maximum of five days.

When to infest

Best results come by infesting new areas during spring and early summer, from September to December. Maximum growth and spreading occurs in the summer months of December to February. During the drier and colder months of April to August the mealy bug does not die, but little growth and multiplication occurs. Introduction of mealy bug during autumn and winter will not be lost, but little effect is seen until the following summer.

How soon to expect results

Mealy bugs are generally more active and effective on harrisia cactus growing underneath shrubs and trees, so results will be seen more quickly in these areas than in cactus growing in the open. Best results are obtained when infesting plants that have actively growing new shoots.

During wet summers in northern and central Queensland, the growing points of stems will begin to curl after about six weeks.

By the end of the first summer, damage (severe twisting) will be widespread in infested plants. If the initial infestation was sufficiently heavy, no fruit or growth will occur during the second year, and the cactus will begin to die during the third year. Seedlings and regrowth shoots will continue to be present but by the end of the fourth year there should be very little cactus left.

In the southern portion of the state, where temperatures are lower, the mealy bug still provides control but the process takes longer. However, the mealy bug will do better on cactus in the open, rather than in the shade, as temperatures are higher in the open.

Where to obtain mealy bugs

If you cannot obtain mealy bugs from your own property or neighbour, contact the vegetation management, weed control, or environmental officer at your local government.

Foliar application of registered herbicides provides effective control, but can be costly over large areas. Before using any herbicide always read the label carefully. All herbicides must be applied strictly in accordance with the directions on the label.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

Figure 1 Distribution of harrisia cactus in Queensland

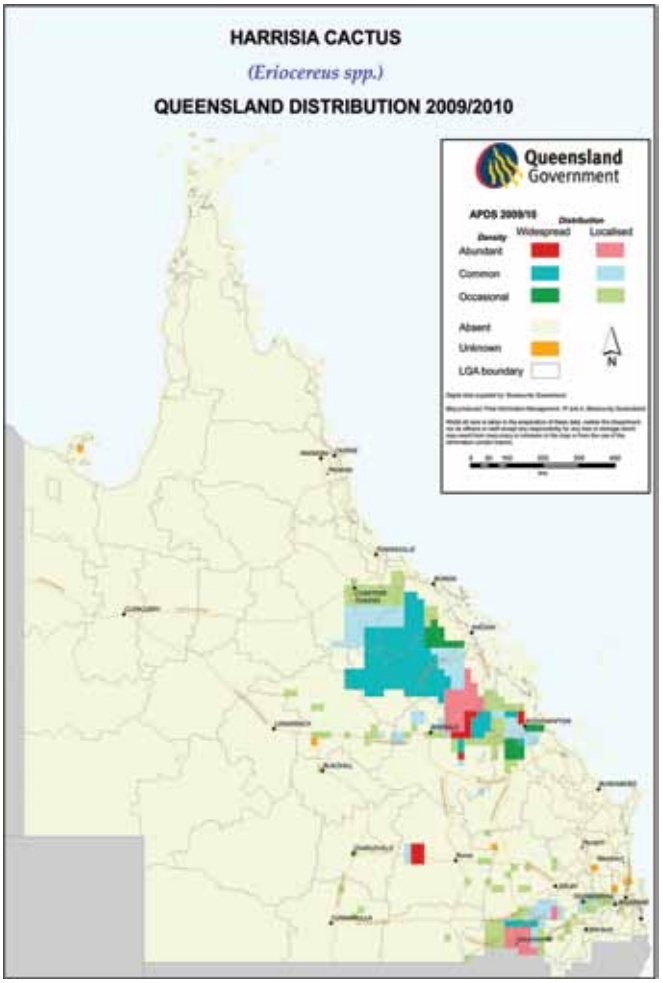


Table 1 Herbicides registered for the control of harrisia cactus

Situation	Herbicide active ingredient	Rate	Comments
Land – non-agricultural land Land – rights of way	dichlorprop as K salt (600 g/L)	1 L/60 L water	Good soil moisture essential. Spray plant when actively growing to run-off point. A follow-up treatment may be necessary.
Land – commercial/industrial/public Land – rights of way, pastures Pastures – native	metsulfuron-methyl (600 g/kg) (e.g. Brush-Off®)	20 g/100 L water + surfactant	Spray plant when actively growing to run-off point. A follow-up treatment may be necessary
Agricultural land – non-crop Forests – timber production Land – commercial/industrial/public Land – rights of way, pastures	triclopyr as butotyl (240 g/L) + picloram as ioe (120 g/L) (e.g. Access®)	1 L/60 L diesel	Spray plant when actively growing. Apply as overall spray, wetting all areas of the plant to ground level
Land – around buildings Land – commercial/industrial/public Land – rights of way	triclopyr as butotyl (75 g/L) +metsulfuron-methyl (28 g/L) (e.g. Ultimate®)	0.5 L/100L	––
Agricultural land – non-crop Forests – timber production Land – commercial/industrial/public Land – rights of way, pastures	triclopyr as tea (200 g/L) + picloram as tipa (100 g/L) (e.g. Tordon DSH®)	5 L/100 L water 2.5 L/100 L water	Spray plant when actively growing. Treat all stems thoroughly

Read the label carefully before use. Always use the herbicide in accordance with the directions on the label.

Mother-of-millions

Bryophyllum delagoense (syn. *B. tubiflorum, Kalanchoe delagoensis*), *Bryophyllum × houghtonii* (syn. *B. daigremontianum × B. delagoense, Kalanchoe × houghtonii*)

Mother-of-millions are escaped ornamental plants originating in Madagascar. Five species are commonly naturalised in Queensland, with one species and a hybrid increasing over substantial areas. It is well adapted to dry areas because of its succulent features.

As the name suggests, one plant can reproduce a new general from masses of embryoids (plantlets) that are formed on the leaf edges. This makes these plants hard to eradicate. Follow up controls are essential.

These plants, especially their flowers, are poisonous to stock and occasionally cause a significant number of cattle deaths. When cattle are under stress or in unusual conditions they are more likely to eat strange plants. Shifting cattle to new paddocks, moving stock through infested rubbish dumps and reduction of availability of feed due to flood or drought can all contribute to poisoning. Since the plant flowers from May to October (during the dryer months of the year) the scarcity of feed may cause cattle to consume lethal amounts of mother-of-millions.

Poisoned cattle show signs of dullness, loss of appetite, diarrhoea and heart failure. Some cattle may drool saliva or dribble urine. There are two responses to poisoning:

1. acute—where cattle die within a day
2. chronic—where cattle may take up to five days to die.

Some cattle may make a slow recovery if insufficient plant material was eaten.

Poisoned cattle must be treated within 24 hours of consuming the plant. The treatment is intense and needs to be given by a veterinarian, or under their direction, because of the drugs and materials used. The treatment is costly—$70 or more for one adult cow, plus veterinary fees.

Declaration details

Bryophyllum delagoense syn. *B. tubiflorum, Kalanchoe delagoensis* and the hybrid *Bryophyllum × houghtonii* syn. *B. daigremontianum × delagoense, Kalanchoe × houghtonii* are declared Class 2 plants under the *Land Protection (Pest and Stock Route Management) Act 2002*.

PP33 June 2011

A Class 2 pest is one that has already spread over substantial areas of Queensland, but its impact is so serious that we need to try and control it and avoid further spread onto properties that are still free of the pest. By law, all landholders must try to keep their land free of Class 2 pests and it is an offence to keep or sell these pests without a permit. A local government may serve a notice upon a landholder requiring control of declared pests.

Description and general information

Mother-of-millions are erect, smooth, fleshy succulent plants growing to 1 m or more in height.

All species form tall flower spikes in winter with clusters of bell-shaped flowers. Each species has a distinctive leaf shape, but all produce small plantlets along the edges of the leaves. These plantlets drop readily, develop roots and establish quickly to form a new colony.

Bryophyllum delagoense syn. *B. tubiflorum* and *Kalanchoe delagoensis* (common mother-of-millions, mission bells, Christmas bells) has grey-brown, fleshy, tubular-like leaves with up to seven projections at the tip of each leaf. The flowers are orange-red and occur in a cluster at the top of a single stem. Seeds can germinate for some years.

Bryophyllum × houghtonii syn. *B. daigremontianum × B. delagoense, Kalanchoe × houghtonii* (hybrid or crossbred mother-of-millions) has similar flowers arranged in a branched cluster at the top of the stem. Its leaves are boat shaped with thick stalks and notches along the edges of the leaves.

A third species, *Bryophyllum pinnatum (*resurrection plant, live-leaf), is also problematic but is not a declared pest plant. This plant has yellow-green, oval, fleshy leaflets with wavy edges and up to five leaflets per leaf. Its flowers are yellowish-green, often tinged with pink, and occur in loose clusters on stalks growing at intervals along the upper portion of the stem.

Habitat and distribution

These popular garden plants have escaped and spread in various areas of Queensland. They have become a problem in pasture lands in the central highlands around Clermont, Emerald and Dingo, and the Burnett, Moreton and Darling Downs scrub regions. The plants establish well in leaf litter or other debris on shallow soils in shady woodlands, and often grow on roadsides, along fence lines and around old rubbish dumps. They can spread from these areas, especially in flood, and establish if pastures are run down. They are adapted to dry conditions and can survive long periods of drought with crassulacean acid metabolism.

Prevention

The best form of weed control is prevention. Always treat weed infestations when small—do not allow weeds to establish. Weed control is not cheap, but it is cheaper to do it now rather than next year, or the year after. Proper planning ensures you get value for each dollar spent.

Permanent control of mother-of-millions infested areas is best ensured by establishing more desirable plants in that location to compete successfully with future mother-of-millions seedlings and plantlets. This is best achieved through soil preparation, replanting, fertilising and using the area more productively.

Ensure scattered infestations and small dumping areas on properties are regularly checked and cleaned up. Day-to-day hygiene management will help prevent establishment of these weeds.

Co-operative control upstream and downstream of problem areas will help prevent re-infestation from other areas.

To prevent poisoning, keep stock (especially hungry stock) away from infested areas until the plants are controlled.

Control

Look at your weed problem carefully. Should you contain the weed to stop new infestations developing while you reduce existing ones? What are you required to do by legislation? How does weed control fit into your property plan? What can you do to restore and prevent re-establishment?

The best approach is usually to combine different methods. Control may include chemical, mechanical, fire and biological methods combined with land management changes. The control methods you choose should suit the specific weed and your particular situation.

Fire

When suitable (e.g. after grading firebreaks), burn infestations and the accompanying debris on which mother-of-millions plants thrive. This is the most economical form of control, encourages grass competition and lessens the problem for following years, requiring only spot spraying with selective herbicides.

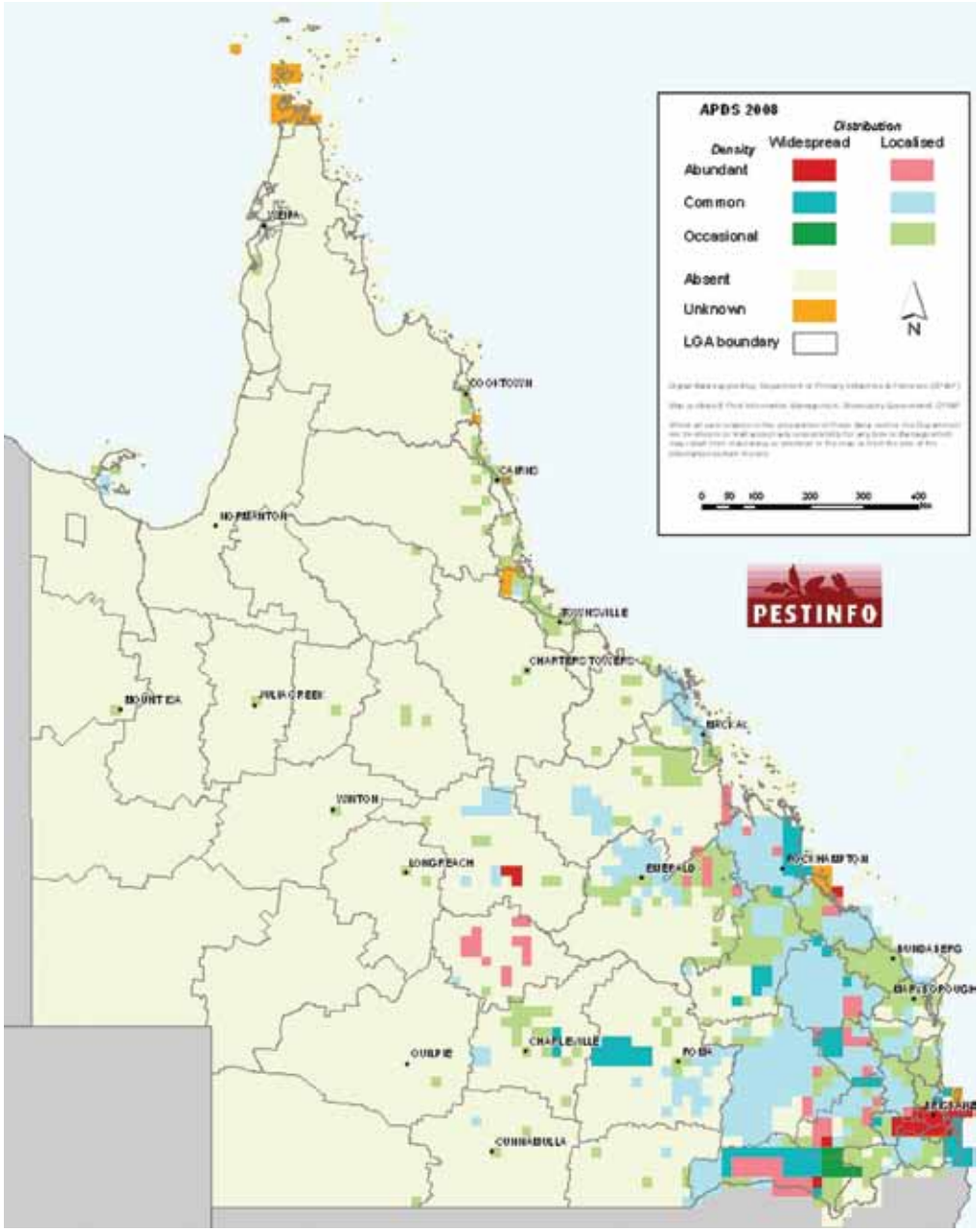


Figure 1. Distribution of mother-of-millions in Queensland

Biological control

The South African citrus thrips is present in Queensland and is quite widespread through the south of the state. This thrips damages the outer tissue of the mother-of-millions plant and also lays its eggs under the outer tissue. Where high populations of thrips exist, the number of viable plantlets and flowers forming on mother-of-millions is reduced.

The thrips populations vary from year to year, according to mother-of-millions populations and climate. The South African citrus thrips should not be seen as a long term control strategy—only a control option to complement other techniques such as herbicide treatment and burning.

South African citrus thrips adult

South African citrus thrips damage to mother-of-millions

Mechanical control

For small areas, pull up plants by hand and burn on a wood heap. Alternatively, bag the plants and dump them in a bin, the contents of which are buried at your councils refuse tip rather than being recycled into mulch.

Herbicide control

Before using any herbicide always read the label carefully. All herbicides must be applied strictly in accordance with the directions on the label. Where the addition of a wetting agent is recommended, always use a commercial wetting agent or surfactant.

Mother-of-millions may be controlled with herbicides at any time of the year, but infestations are easiest to see in winter when the plants are in flower. Treating infestations at this time of year also has the benefit of preventing new seeds from developing on common mother-of-millions.

Table 1 details the herbicides registered for mother-of-millions control.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

Table 1. Herbicides registered for the control of mother-of-millions

Situation	Herbicide	Rate	Comments[1]
Pastures, non-crop land	2,4-D acid (AF 300)	7 L/1000 L water per ha 70 ml/10 L water	Overall spray handgun Overall spray knapsack
Pastures, rights of way, non-crop land, forests, non-agricultural land, commercial/industrial areas	picloram + triclopyr (e.g. Grass-up, Grazon DS, Picker)	50 ml/10 L water	Overall spray knapsack Apply at flowering
	fluroxypyr	600 ml/100 L water + sufactant	Apply to seedlings and young plants before flowering
	picloram + triclopyr + aminopyralid (e.g. Grazon Extra)	50 ml/10 L water	Add 100% concentrate non-ionic surfactant (e.g. BS 1000) at 100 ml/100 L water Apply at flowering

Read the label carefully before use. Always use the herbicide in accordance with the directions on the label.

Note:

1. Thorough, even coverage of leaves and plantlets is necessary.

CS0478 06/11

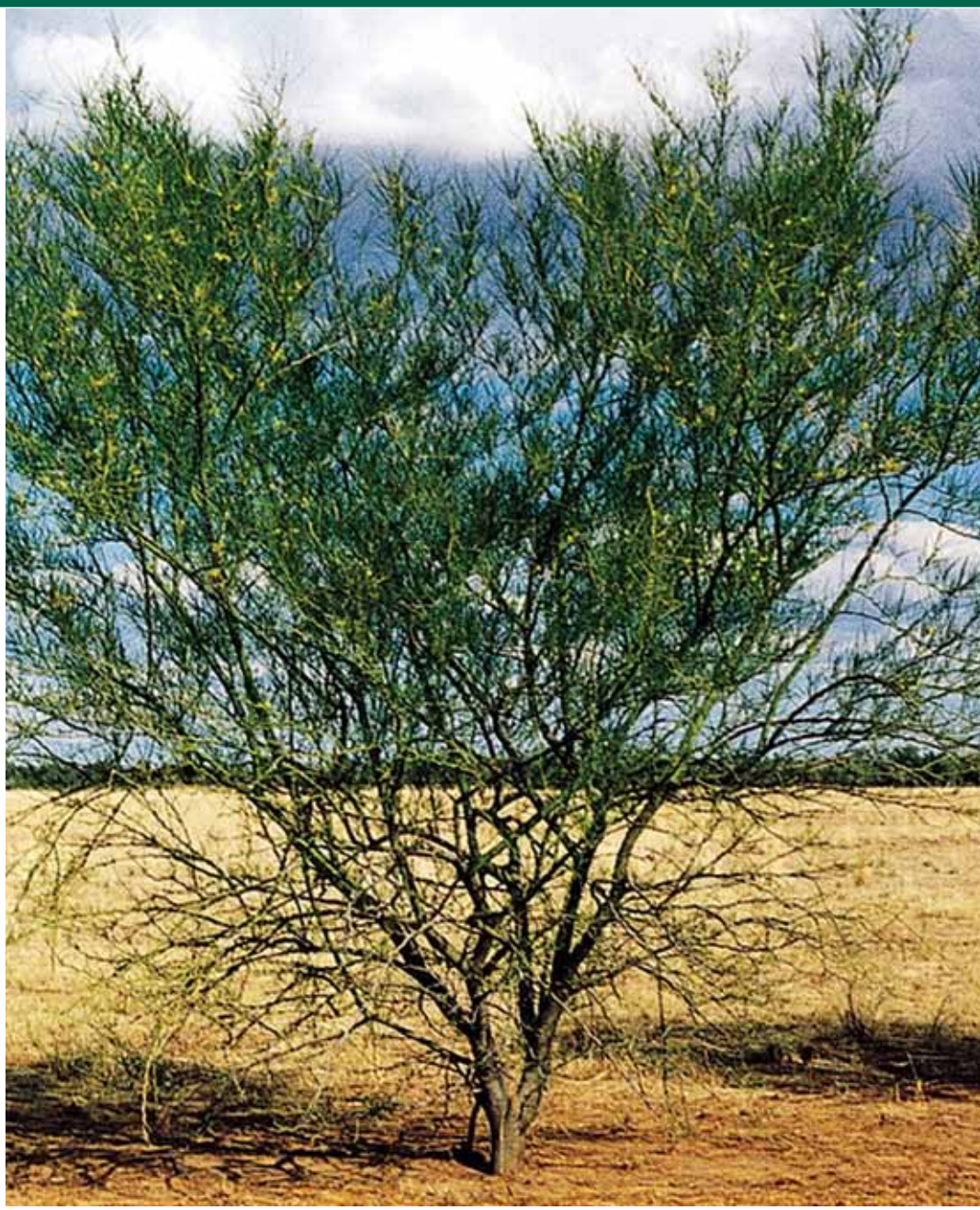
Fact sheet

DECLARED CLASS 2 PEST PLANT

Parkinsonia

Jerusalem thorn or jelly bean tree

Parkinsonia aculeata



Parkinsonia is thought to be native to tropical America but has spread throughout the world as an ornamental and shade tree. It has been recognised in Australia as a Weed of National Significance.

Declaration details

Parkinsonia is a declared Class 2 plant under *Land Protection (Pest and Stock Route Management) Act 2002*. Declaration requires landholders to control declared pests on the land and waters under their control. A local government may serve a notice upon a landholder requiring control of declared pests.

WEEDBUSTERS

Queensland Government

PP36 June 2011

Description and general information

Size and appearance

A hairless shrub or small tree that rarely grows any more than 10 m high, Parkinsonia has slender green photosynthetic zigzag branches armed with sharp spines.

Leaves

Its leaves have a short, spine-tipped stalk, with leaf branches 20–40 cm long, flattened with small, oblong leaflets along each edge.

Flowers

Parkinsonia flowers are yellow, fragrant, five petalled, each on a long, slender drooping stalk. Seeds are oval and hard, about 15 mm long, and borne in pencil-like pods 5–10 cm long, constricted between the seeds.

Lifecycle

Parkinsonia is fast growing and may flower in early summer of its second or third year of growth. Once established, flowering can occur opportunistically to exploit variable seasonal conditions. Pods mature in late summer, float on water and hence are readily dispersed by flood waters.

Under favourable warm and wet field conditions, most seeds germinate within 2 years. However, a small proportion of seed may remain dormant for longer periods if it's under heavy pasture cover, buried deeper in the soil profile, when inundated or when insufficient rain has fallen.

Habitat and distribution

As parkinsonia is adapted to an extremely wide range of soil types, there is little doubt that it will continue to spread through watercourses and adjoining areas throughout the sub-humid and semi-arid environments of Queensland.

The most vulnerable areas are the lower Gulf of Carpentaria region, Lake Eyre catchment especially the Channel country, Central Highlands and Cape York.

Control

Biological control

Three species of insects have been introduced into Australia as biological control agents against parkinsonia.

Parkinsonia seed beetles *Penthobruchus germaini* and *Mimosetes ulkei*.

Both *Penthobruchus germaini* and *Mimosetes ulkei* are seed beetles that attack only parkinsonia and whose larvae destroy mature parkinsonia seeds.

Penthobruchus germaini is a small (5 mm – 6 mm long) brown beetle from Argentina. It was first released in 1995 and has established much more readily than *Mimosestes*. It has established readily at all release sites and spreads rapidly.

Penthobruchus can exert heavy pressure on parkinsonia seeds in some areas. In the field its presence is indicated by white eggs against a darker background of the pods. Round holes in the pods indicate that beetles have emerged.

Mimosestes ulkei is a small (about 5 mm long) two-tone grey beetle from the USA. While it is established at several sites, it does not establish as readily as *Penthobruchus*. It has potential to contribute to the destruction of parkinsonia seeds. In the field, round emergence holes are the only external indication of its presence.

Parkinsonia leaf bug *Rhinacloa callicrates* *Rhinacloa callicrates* is a small green bug (about 3 mm long) imported from the USA. It feeds on leaves and shoots of parkinsonia resulting in tiny round white spots where it destroys photosynthetic tissue. It is well established in Queensland but it has no significant impact on parkinsonia.

Further biological control studies

Research has continued in recent years to survey the native range of parkinsonia for potential new agents. Several prospective insects have been identified and will be subject to host-testing studies prior to release.

Dieback research

Naturally occurring fungal pathogens have been identified as causing dieback within many infestations of parkinsonia across Northern Australia. Studies are continuing regarding the use of these pathogens as biological control tools.

Mechanical control

Initial clearing by stick raking, blade ploughing or ripping is effective, however:

- it is restricted to reasonably level areas away from watercourses
- clearing will hasten seed germination, necessitating follow-up control either mechanically or chemically.

Establishing improved pasture will aid in managing parkinsonia by competition.

Fire

Fire may be a useful tool for the management of parkinsonia infestations. Kill rates may vary from 30% to 90% with best results obtained from slow moving fires.

Fire will destroy seedlings if sufficient fuel load is present, but mature plants will usually survive.

Herbicide control

Herbicides registered for the control of parkinsonia are listed in Table 1.

Aerial application

Aerial application is undertaken by purpose-built applicators by helicopter. This is useful for dense, strategic infestations although it may be expensive on a broad scale.

Foliar (overall) spray

This is an effective control method for seedlings up to 1.5 m tall. Spray leaf and stems to point of runoff. A wetting agent must be used.

Basal bark spray

For stems up to 15 cm diameter, carefully spray around the base of the plant to a height of 30 cm above ground level. Larger trees may be controlled by spraying to a greater height, up to 100 cm above ground level.

Plants should be actively growing and preferably flowering. Field experience has shown that good soil moisture is essential for effective control.

Because parkinsonia infested areas are often subject to flooding, care is needed to ensure mud and flood debris does not prevent spray penetration to the bark. The trunk may need to be cleared before spraying. Addition of petrol or A-1 jet fuel will aid penetration.

Cut stump treatment

Cut stump treatment may be performed at any time of the year. Cut stems off horizontally as close to the ground as possible. Immediately (within 15 seconds) swab or spray the cut surface and associated stem with herbicide mixture.

Soil application

Use one dose of herbicide per metre of tree height. Place doses close to tree trunk, either with spot gun on clear bare ground, or underground with ground injector. Rain or sufficient soil moisture is required before herbicide is taken up by the plant.

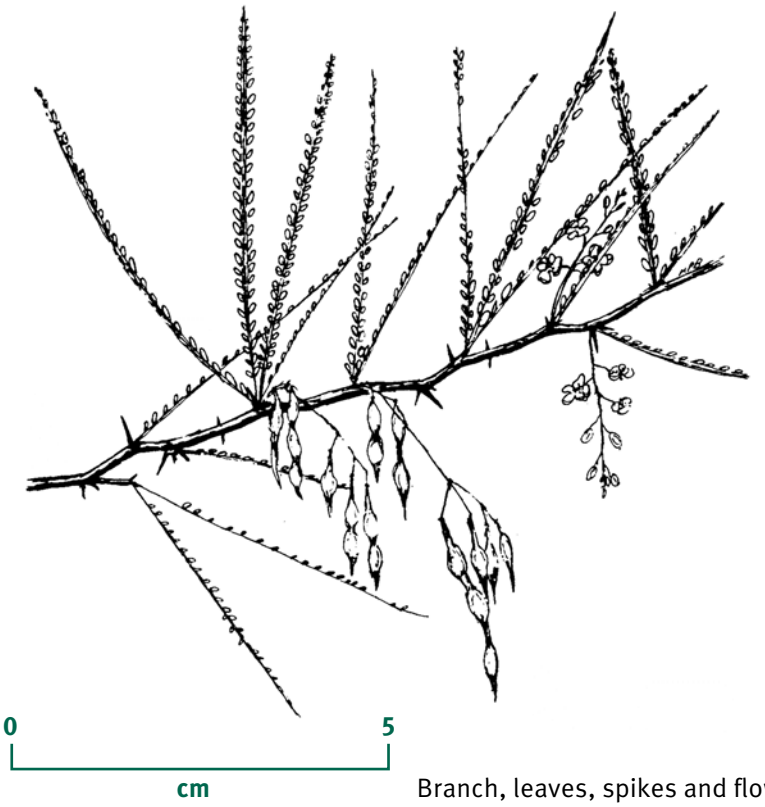
Do not use near watercourses or within a distance equal to at least twice the height of desirable trees.

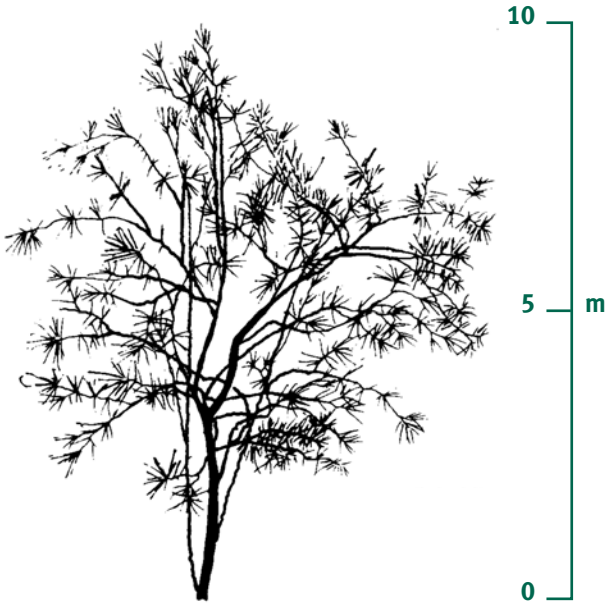
Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

Table 1 Herbicides registered for the control of parkinsonia.

Situation	Herbicide	Rate	Optimum stage and time	Comments
Aerial application	Aminopyralid, picloram and tricopyr e.g. Grazon Extra DS®	3 L/ha	Seedlings 1–2 m tall, or 12–24 months old	Application by helicopter only. Addition of 1 L/ha of Uptake® wetting agent
Foliar (overall spray)	Aminopyralid, picloram and tricopyr e.g. Grazon Extra DS®	0.35 L/100 L water	Seedlings less than 2 m tall and actively growing	Wet plant thoroughly. Use wetting agent
Basal bark spray	Triclopyr and picloram e.g. Access®	1 L/60 L diesel	As above. Stems up to 5 cm diameter	Do not treat wet stems
Cut stump	Triclopyr and picloram e.g. Access®	1 L/60 L diesel	Any time of year	Cut close to ground level and treat **immediately**
Soil application	Hexazinone e.g. Velpar L® (via spotgun)	4 ml per spot—1 spot for each shrub/tree	Any time, but needs moisture to activate chemical	Shrubs/trees up to 5 m tall
	Tebuthiuron e.g. Grazon Extra DS®	1 to 1.5 g/m^2	Any time, but needs moisture to activate chemical	Refer to label for critical comments





Branch, leaves, spikes and flowers

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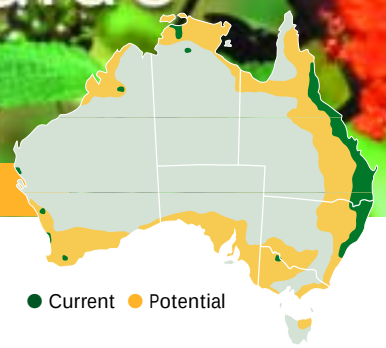
Weed Management Guide

Lantana – *Lantana camara*



Lantana (*Lantana camara*)

The problem

Lantana is a *Weed of National Significance*. It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts.

Lantana forms dense, impenetrable thickets that take over native bushland and pastures on the east coast of Australia. It competes for resources with, and reduces the productivity of, pastures and forestry plantations. It adds fuel to fires, and is toxic to stock.

Lantana is a serious threat to biodiversity in several World Heritage-listed areas including the Wet Tropics of northern Queensland, Fraser Island and the Greater Blue Mountains. Numerous plant and animal species of conservation significance are threatened. It is listed as the most significant environmental weed by the South-East Queensland Environmental Weeds Management Group.

It is a problem in gardens because it can cross-pollinate with weedy varieties to create new, more resilient forms.

Lantana is a significant weed of woodlands and pastures east of the Great Dividing Range.
Photo: Qld DNRM

The weed

There are two main forms of lantana in Australia: a cultivated form planted in gardens and a weedy variety found in bushland and pastures. The cultivated form of lantana is non-thorny, produces few seeds and is compact in shape. The weedy form is a prolific seeder with straggly, thorny stems. Both forms include many varieties, which differ from each other in shape, flower colour, prickliness, response to enemies and toxicity.

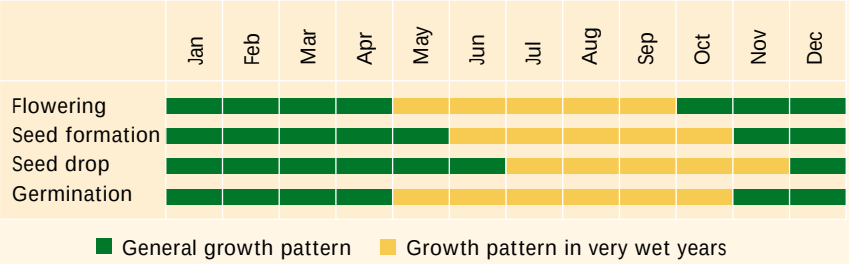
Weedy lantana is a much branched, thicket-forming shrub, 2–4 m tall. The woody stems are square in cross-section and hairy when young but become cylindrical and up to 150 mm thick with age. The ovate (ie tear-shaped) leaves (20–100 mm long) occur in opposing pairs along the stem. The leaves are rough and finely hairy and emit a pungent odour when crushed. Each flower head is made up of 20–40 flowers, ranging in colour from white, cream or yellow to orange, pink, purple and red. The fruit has many berries, which ripen from green to shiny purple-black and contain a single pale seed. Lantana has a short taproot and a mat of many shallow side roots.

Key points

- Lantana is a thicket-forming shrub that has spread from gardens into pastures, woodlands and rainforests on the east coast.
- It typically invades disturbed land and river margins, extending its range in response to rainfall.
- It threatens agriculture and pastoral production, forestry and biodiversity of conservation areas, and may be toxic to stock.
- The highest priority for lantana control is preventing its spread into northern Australia and west of the Great Dividing Range.
- Integrated control should combine fire, mechanical, chemical and biological methods, and revegetation.

Natural Heritage Trust
Helping Communities Helping Australia
An Australian Government Initiative

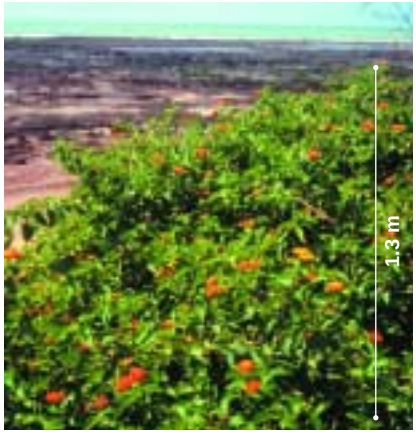
Growth calendar



Lantana flowers whenever the soil is moist and the air is warm and humid. For much of its range along the Queensland and New South Wales coasts, this results in almost continuous flowering and fruiting. Further inland, peak flowering occurs several weeks after soaking rain (25 mm or more) and is usually accompanied by good fruit set.

Germination most frequently occurs following the first summer storms, but may occur at any time of the year when sufficient moisture is present. Initial seedling growth is slow until the roots become established, after which close stems intertwine and begin to form thickets. Flowering does not usually commence until early in the following summer and then continues until March or April.

Lantana can resprout from the base if the shoot dies, extending the life of individual plants.



Flowering lantana infestation in Darwin, NT, in December.
Photo: Colin G. Wilson

How it spreads

Lantana spreads in two ways. Layering is a form of vegetative reproduction where stems send roots into the soil, allowing it to quickly form very dense stands and spread short distances. Also, birds and other animals such as foxes consume and pass the seed in their droppings, potentially spreading it over quite large distances. The germination rate of fresh seed is generally low, but improves after being digested.

Butterflies, bees and other insects are attracted by the nectar and pollinate lantana flowers. About half of the flowers produce seeds, typically 1–20 seeds on each flower head. Mature plants can produce up to 12,000 seeds every year. Seeds are thought to remain viable for several years under natural conditions.

Lantana is allelopathic and can release chemicals into the surrounding soil which prevent germination and competition from some other plant species.

First recorded in the Adelaide Botanic Gardens in 1841, lantana spread to east coast gardens and was recorded as a weed in Brisbane and Sydney in the early 1860s. It is now found across four million hectares of land east of the Great Dividing Range, from Mount Dromedary in southern New South Wales to Cape Melville in northern Queensland. Isolated infestations exist in the Top End of the Northern Territory, around Perth in Western Australia, and on Lord Howe and Norfolk Islands. Although present Australia wide as a garden ornamental, it has not naturalised to any serious extent elsewhere.

When ripe, birds and animals consume fruit and spread seed.
Photo: Colin G. Wilson

Where it grows

Lantana can grow in high-rainfall areas with tropical, subtropical and temperate climates. It does not tolerate salty or dry soils, waterlogging or low temperatures (<5ºC). It thrives on rich, organic soils but also grows on well-drained clay and basalt soils. Sandy soils tend to dry out too rapidly for lantana unless soil moisture is continually replenished. It has been reported at altitudes up to 1000 m in Queensland.

Lantana invades disturbed sites, especially open sunny areas, such as roadsides, cultivated pastures and fencelines. From there it can invade the edges of forests, but it does not fare as well under a heavy canopy as it is not very shade tolerant. Therefore, it is not a problem in intact tropical rainforest but can quickly spread there if the canopy opens out.

Lantana occurs naturally in Mexico, the Caribbean and tropical and subtropical Central and South America. It is considered a weed in nearly 50 countries.

Another weedy species of lantana

Another species of lantana is a popular ornamental that is considered a weed when present in natural ecosystems. Creeping lantana (*Lantana montevidensis*) occurs in coastal and subcoastal Queensland and as far south as Sydney. It is fairly similar to *Lantana camara* but does not have thorns, has mainly pink or purple flowers and trails along the ground, only growing to a height of half a metre. It is also toxic and readily displaces native vegetation.

Creeping lantana (*Lantana montevidensis*) is naturalised in coastal and subcoastal Qld and only grows to a height of half a metre. It is toxic and readily displaces native vegetation. Photo: John Swarbrick

Potential distribution

Lantana may be able to spread west of the Great Dividing Range, and could expand its range throughout southern Victoria, South Australia and southwestern Western Australia.

What to do about it

Lantana is extremely widespread and abundant. Because it is so well established on the east coast, and prevention of spread is the most cost-effective weed management tool, the highest priority for lantana management is to prevent its spread into uninfested areas. This will require three main actions.

1. Restricting further importation of lantana into Australia. Any new varieties brought in could escape cultivation and naturalise, or could cross-breed with naturalised varieties, leading to hardier new varieties more resistant to control.
2. Restricting the sale and use of lantana in gardens as these are potential sources of new infestation and new varieties. There are native and less weedy exotic ornamental alternative species.
3. Strategically controlling infestations that threaten areas where lantana is not yet a weed. Control methods are outlined below.

Integrated management

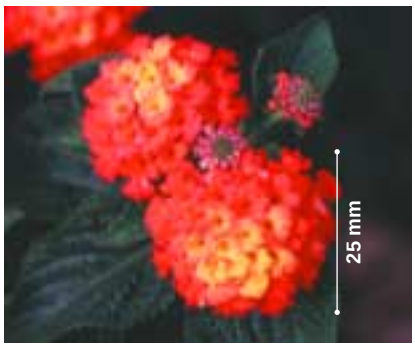
An integrated approach that uses a variety of control methods gives best results when dealing with lantana. A range of methods including herbicides, mechanical removal, fire, biological control and revegetation should be used. Best results are obtained by working from areas of light infestation towards heavier infestation, and long-term follow-up control is required after initial attempts. Minimise both disturbance to land and excessive use of fire to retain vigorous native vegetation and reduce the opportunity for lantana to become established.

Herbicide control – effective but expensive

There are many herbicides registered for lantana control and three main application techniques. Spraying the entire plant (foliar spraying) usually kills plants that are less than 2 m high. Herbicides applied to the lower bark of the stems (the basal bark technique) or immediately painted onto a freshly cut stump (the cut-stump technique) are useful for larger plants. Both of these techniques are time consuming because they require treatment of each stem, which can be difficult to access in large stands of lantana. High costs make herbicide control uneconomical for large infestations, except when there are no other options (eg on steep slopes, where helicopter spraying may be required).

For best results, integrate fire, mechanical, chemical and biological control and revegetation

Herbicides, especially those that are foliar applied, are most effective when plants are actively growing. With lantana, best results are obtained six weeks after good rains (at least 35 mm) when minimum temperatures exceed 15ºC. In Queensland the spraying season generally lasts from early summer to autumn, but earlier control will potentially allow follow-up in the same growing season.



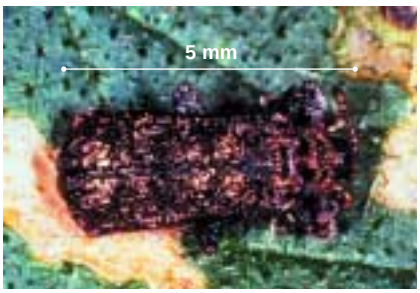
Lantana flowers can be one colour (*left*), or a mix of two (*centre*) or more colours (*right*). Photos: Colin G. Wilson

Weed control contacts

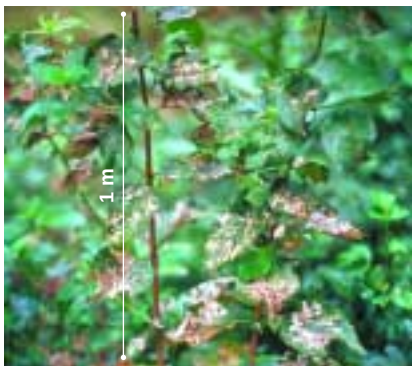
State / Territory	Department	Phone	Email	Website
ACT	Environment ACT	(02) 6207 9777	EnvironmentACT@act.gov.au	www.environment.act.gov.au
NSW	NSW Agriculture	1800 680 244	weeds@agric.nsw.gov.au	www.agric.nsw.gov.au
NT	Dept of Infrastructure, Planning and Environment	(08) 8999 5511	weedinfo.ipe@nt.gov.au	www.nt.gov.au
Qld	Dept of Natural Resources and Mines	(07) 3896 3111	enquiries@nrm.qld.gov.au	www.nrm.qld.gov.au
SA	Dept of Water, Land and Biodiversity Conservation	(08) 8303 9500	apc@saugov.sa.gov.au	www.dwlbc.sa.gov.au
Tas	Dept of Primary Industries, Water and Environment	1300 368 550	Weeds.Enquiries@dpiwe.tas.gov.au	www.dpiwe.gov.au
Vic	Dept of Primary Industries/Dept of Sustainability and Environment	136 186	customer.service@dpi.vic.gov.au	www.dpi.vic.gov.au www.dse.vic.gov.au
WA	Dept of Agriculture	(08) 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au
Australia wide	Australian Pesticides and Veterinary Medicines Authority	(02) 6272 5852	contact@apvma.gov.au	www.apvma.gov.au

Note that herbicides vary in their effectiveness on different lantana varieties. The red flowered varieties are normally the least susceptible to herbicides while the pink forms are the easiest controlled. Consult your local council or state/territory weed management agency about which herbicides and applications are most suitable for your infestation of lantana. State and territory contact details are listed above, including contacts for the Australian Pesticides and Veterinary Medicines Authority, which hosts the PUBCRIS database. This database contains information on all herbicides that are registered for use on weeds in each Australian state and territory.

When using herbicides always read the label and follow instructions carefully. Particular care should be taken when using herbicides near waterways because rainfall running off the land into waterways can carry herbicides with it. Permits from state or territory Environment Protection Authorities may be required if herbicides are to be sprayed on riverbanks.



Both adults (*above*) and larvae of the leaf-mining beetle *Octotoma scabripennis* feed on lantana leaves. It is present in most lantana infestations, particularly where it is shady and wet in subtropical, coastal areas.
Photo: Michael Day, Qld DNRM



Damage to lantana leaves caused by the leaf-mining beetle *Octotoma scabripennis*.
Photo: Michael Day, Qld DNRM

Mechanical and physical control – suitable for small infestations

Lantana can be removed mechanically or physically in several ways, including stickraking, bulldozing, ploughing and grubbing. These techniques are mainly suited to medium-sized infestations and require extensive follow-up, as they invariably lead to regrowth if the rootstock is not removed, or seedling germination when heavy machinery disturbs the soil. Any soil disturbance should be avoided on steep inclines or in gullies. A permit may be required if native plants are to be affected by mechanical control – check with your local council or state/territory weed management agency.

Fire – inexpensive but caution must be exercised

Fire is often used prior to mechanical or herbicide control to improve their effectiveness, or as a follow-up to such methods. It can also provide some control when used on its own under the right conditions. It is most effective when fires are hot and the lantana is actively growing. In southeastern Queensland best results from fire are achieved during early summer. In New South Wales controlled burns are used opportunistically, mainly in late winter and spring before conditions become too dry and fires could escape control.

Fire is relatively inexpensive and well suited to dense infestations, but the risks to people and property must be carefully managed. Burning is not recommended in rainforest and vine thickets because they are highly sensitive to fire. Disturbance in these habitats may actually promote lantana if the canopy is opened up. A permit may be required to burn – check with your local council or state/territory weed management agency.

Biological control

In 1902 the first attempt at biological control of a weed targeted lantana in Hawaii. In Australia biological control agents were first introduced in 1914; so far, 30 species have been introduced. Research into biological control is ongoing, and several agents are currently being examined for suitability of release.

Of the 16 species that have established, four insects have had a major impact on lantana. They are:

- a sap-sucking bug (*Teleonemia scrupulosa*) (Sydney to northern Queensland).
- a leaf-mining beetle (*Uroplata girardi*) (northern Queensland to Sydney).
- a leaf-mining beetle (*Octotoma scabripennis*) (Sydney to south of Rockhampton).
- a seed-feeding fly (*Ophiomyia lantanae*) (southern New South Wales to northern Queensland).

The biological control agents vary in their effectiveness against the many different types of lantana. For example, lantana can drop its leaves when stressed, depriving some agents of their food.

Revegetation – useful in pastures and forests

Revegetation of a treated site is a key component of a lantana management program. Revegetation helps to reduce erosion, adds fuel for future burning in pastures and is vital in limiting the re-establishment of lantana and other weeds. Sowing an improved pasture that outcompetes and smothers lantana seedlings is assisted by withholding grazing for the first six months, and only allowing light grazing for the next 12–18 months. In forested areas either planting trees or encouraging naturally occurring seedlings will help to shade out lantana in the longer term. Check with your local council or state/territory weed management agency about appropriate species for revegetating pastures or forests in your area.

Follow-up

Follow-up control after an initial effort may include any or all of the above methods. Established pastures can be burnt to control significant lantana regrowth, and any small patches can be spot sprayed with a registered herbicide or grubbed out. In forested areas herbicides are recommended to control regrowth, typically requiring three follow-up sprays after the initial control effort.

Legislation

Landholders are required to reduce lantana infestations throughout some regions of Queensland, New South Wales and the Northern Territory. The sale of lantana in Queensland was banned in late 2003. Lantana importation is prohibited in Western Australia. Check with your local council or state/territory weed management agency for relevant details.

Acknowledgments

Information and guide revision: Michael Day (Qld DNRM/Weeds CRC), Tony Grice (CSIRO/Weeds CRC), Richard Carter (NSW Dept of Agriculture/Weeds CRC), Andrew Clarke (Qld DNRM), Georgina Eldershaw (NSW NPWS), Jim Sloane (Sutherland Shire Environment Centre) and John Thorp (National Weeds Management Facilitator).

Maps: Australian Weeds Committee.

...case study

Lantana control at Towra Point, Botany Bay, New South Wales

Towra Point Nature Reserve in Botany Bay contains habitats of high conservation status, including wetlands of international importance and open woodlands that are unique in the Sydney region. A coastal rainforest in the region was recently listed as an endangered ecological community under the New South Wales *Threatened Species Conservation Act 1995*. It includes the magenta brush cherry (*Syzygium paniculatum*), a vulnerable tree species.

By the 1990s, lantana made up almost 75% of the vegetation cover in some parts of the reserve and was limiting the regeneration of native species, particularly around a freshwater wetland called Weedy Pond. The Friends of Towra, a volunteer group, commenced weed control in the Weedy Pond rainforest in 1996. In 1998 the Sutherland Shire Environment Centre, working in conjunction with the National Parks and Wildlife Service, gained Coastcare funding to supplement the volunteer program.

Beginning in March 1998, weed control focused on a corridor connecting the rainforest and a casuarina/banksia forest, following up on previous control and initiating new efforts. Lantana was controlled by a combination of cut-stump herbicide application and manual removal of smaller plants. Other weeds were also controlled when they were encountered.

Work was undertaken about every two months throughout 1998 by volunteers and members of local community groups. Follow-up hand weeding and spot spraying, and further control of primary lantana infestations, were also undertaken throughout 1999. This work involved international backpackers, unemployed people from Green Corps 2000, students and personnel from private enterprise, all of whom volunteered their time. The total area cleared of lantana and other weeds was approximately 75 m wide and 100 m long.

In May 2000 the cleared areas were planted with native vegetation by local Cub Scouts and Venturers and members of the Friends of Towra. Approximately 200 banksias were planted. The training of volunteers and community groups on such issues as weed control techniques, bush regeneration and plant identification was another significant outcome.

At each quarterly follow-up visit to the site, approximately 24 man-hours are required to keep on top of any reshooting and newly germinated lantana, and encourage regeneration of native species. It is expected that lantana will become disadvantaged as canopy cover and shade increases, and less work will be required in the future.

How to control lantana

Quick reference guide

Minimise spread and future impacts

Although lantana is widespread on the east coast of Australia, it is still absent from parts of its potential range. These areas should be protected by:

- preventing the importation of further varieties and species of lantana
- stopping more planting of lantana in gardens
- strategically controlling infestations which threaten uninfested areas.

A control program for dense infestations in pastures

The Queensland Department of Natural Resources and Mines has produced a pest series fact sheet on lantana (PP#34). They advise that herbicides are too expensive to treat large lantana infestations.

A combination of fire and mechanical control makes spot treatment of small patches with herbicides more cost-effective. The following suggested control program for dense infestations in pastures is based on the fact sheet:

1. Exclude stock to allow a fuel load to build up.
2. Bulldoze, stickrake or plough the infestation to add to the fuel load.
3. Burn the infestation after obtaining a permit. Summer burns are more effective than winter burns.
4. Sow an improved pasture. Seek advice of local council or state/territory government agencies for selection of non-weedy pasture species.
5. Continue stock exclusion until pasture has established and set seed.
6. Burn the infestation again after obtaining a permit.
7. Spot spray or grub out any regrowth or seedlings. Spraying is most effective between summer and autumn.
8. Follow-up burning, spraying and/or grubbing will be required for several years.

Lantana can escape from garden plantings into surrounding bushland.
Photo: Tim Schultz

Control options

Type of infestation	Physical	Mechanical	Chemical	Fire	Biological
Small (few plants, small area)	Hand grubbing only suitable for seedlings. Wear gloves for protection from thorns.	Not suitable.	Spot spray plants less than 2 m in height between summer and autumn with a registered herbicide.	Not suitable.	There are four useful biological control agents. They are already distributed throughout their potential range.
Medium (medium density, medium total area)		Bulldoze, plough, stick-rake or slash infestations. Soil disturbance will lead to mass seed germination, so follow up with further controls. Do not use mechanical control in areas susceptible to erosion. A permit may be required.	Spraying is uneconomical for medium or large infestations. Helicopter spraying is used when there is no access for mechanical control, eg very steep slopes.	Under permit, burn in summer with good fuel load of grass and/or mechanically cleared lantana. Also use as follow-up. Do not burn in rainforests.	
Large (many plants, many ha)					

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CRC Weed management

Fact sheet

DECLARED CLASS 2 PEST PLANT

Parthenium weed

Parthenium hysterophorus

Parthenium costs the beef industry a total of $16.5 million per year and cropping industries several million dollars per year.

Declaration details

In Queensland, Parthenium is a Class 2 declared plant.

Under the *Land Protection (Pest and Stock Route Management) Act 2002*, Class 2 declaration requires landholders to control pests on the land and waters under their control. A local government may serve a notice upon a landholder requiring control of declared pests.

WEED BUSTERS

Queensland Government

PP2 June 2011

Description and general information

Size

Parthenium weed is an annual herb with a deep tap root and an erect stem that becomes woody with age. As it matures, the plant develops many branches in its top half and may eventually reach a height of two metres.

Leaves

Its leaves are pale green, deeply lobed and covered with fine soft hairs.

Flowers

Small creamy white flowers occur on the tips of the numerous stems. Each flower contains four to five black seeds that are wedge-shaped, two millimetres long with two thin, white scales.

Lifecycle

Parthenium weed normally germinates in spring and early summer, produces flowers and seed throughout its life and dies around late autumn. However, with suitable conditions (rain, available moisture, mild temperatures), parthenium weed can grow and produce flowers at any time of the year. In summer, plants can flower and set seed within four weeks of germination, particularly if stressed.

Potential damage

Parthenium weed is a vigorous species that colonises weak pastures with sparse ground cover. It will readily colonise disturbed, bare areas along roadsides and heavily stocked areas around yards and watering points. Parthenium weed can also colonise brigalow, gidgee and softwood scrub soils. Its presence reduces the reliability of improved pasture establishment and reduces pasture production potential.

Parthenium weed is also a health problem as contact with the plant or the pollen can cause serious allergic reactions such as dermatitis and hay fever.

Habitat and distribution

Parthenium weed is capable of growing in most soil types but becomes most dominant in alkaline, clay loam soils.

The plant is well established in Central Queensland and present in isolated infestations west to Longreach and in northern and southern Queensland.

Infestations have also been found in northern and central parts of New South Wales and it is capable of growing in most states of Australia.

Control

Prevention and weed seed spread

As with most weeds, prevention is much cheaper and easier than cure. Pastures maintained in good condition, with high levels of grass crown cover, will limit parthenium weed colonisation. Drought, and the subsequent reduced pasture cover, creates the ideal window of opportunity for parthenium weed colonisation when good conditions return.

Parthenium seeds can spread via water, vehicles, machinery, stock, feral and native animals and in feed and seed. Drought conditions aid the spread of seed with increased movements of stock fodder and transports.

Vehicles and implements passing through parthenium weed infested areas should be washed down with water. Wash down facilities are located in Alpha, Biloela, Charters Towers, Emerald, Gracemere, Injune, Monto, Moura, Rolleston, Springsure and Taroom. Particular care should be taken with earthmoving machinery and harvesting equipment. The wash down procedure should be confined to one area, so that plants that establish from dislodged seed can be destroyed before they set seed.

Extreme caution should be taken when moving cattle from infested to clean areas. Avoid movement during wet periods as cattle readily transport seed in muddy soil. On arrival, cattle should be held in yards or small paddocks until seed has dropped from their coats and tails prior to their release into large paddocks. Infestations around yards can be easily spotted and controlled whereas infestations can develop unnoticed in large paddocks.

Particular care should be taken when purchasing seed, hay and other fodder materials. Always keep a close watch on areas where hay has been fed out for the emergence of parthenium or other weeds.

Property hygiene is important. Owners of clean properties should ensure that visitors from infested areas do not drive through their properties. If your property has parthenium weed on it, ensure that it is not spread beyond the boundary or further within the property.

Pasture management

Grazing management is the most useful method of controlling large-scale parthenium weed infestations. Maintain pastures in good condition with high levels of ground and grass crown cover. This may require rehabilitation of poor pastures, followed by a sound grazing maintenance program.

Sown pasture establishment—Poor establishment of sown pastures can allow parthenium weed colonisation. pasture agronomist Aerial seeding prior to scrub pulling is normally beneficial.

Overgrazing—High grazing pressure caused by drought or high stock numbers decreases the vigour and competitiveness of pastures and allows the entry and spread of parthenium weed. Maintenance of correct stock numbers is most important in controlling parthenium weed. pasture agronomist

Pastures spelling—In situations of serious infestation, pasture spelling is essential for rehabilitation. Total spelling is much more effective than simply reducing the

stocking rate. However, overgrazing of the remainder of the property must be avoided.

The most appropriate time for pasture spelling is the spring–summer growing period, with the first 6–8 weeks being particularly important. If the condition of perennial grasses (native or sown) is low, spelling for the entire growing season may be required or introduced grasses may need to be re-sown. Herbicide treatment can hasten the rehabilitation process by removing a generation of parthenium seedlings and allowing grass seedlings to establish without competition. In the presence of parthenium weed, grass establishment is poor.

Grazing during winter should not increase the parthenium weed risk. Most tropical grasses are dormant and can tolerate moderate grazing during this period. However, parthenium weed may germinate and grow at this time.

Fencing—One of the main problems in controlling parthenium weed is the large paddock size and the variability of country within paddocks. The resulting uneven grazing pressures encourage parthenium weed to colonise the heavily grazed country. Ideally, similar land types should be fenced as single units. Fencing can be used to great effect to break up large paddocks, allowing more flexible management such as pasture spelling or herbicide application, options not available previously.

Burning—Burning is not promoted as a control strategy for parthenium weed. However, research suggests that burning for pasture management (e.g. woody weed control) should not result in an increased infestation if the pasture is allowed to recover prior to the resumption of grazing. Stocking of recently burnt areas known or suspected to contain parthenium decreases pasture competition and favours parthenium, ultimately creating a more serious infestation.

Herbicide control

Non-crop areas—Parthenium weed should be sprayed early before it can set seed. A close watch should be kept on treated areas for at least two years.

Small and/or isolated infestations should be treated immediately. Herbicide control will involve a knockdown herbicide to kill plants that are present and a residual herbicide to control future germinations. Repeated spraying may be required even within the one growing season to prevent further seed production.

Extensive infestations will require herbicide treatment in conjunction with pasture management. Timing of spraying is critical so that parthenium weed is removed when plants are small and before seeding has occurred. Grasses should be actively growing and seeding so that they can recolonise the infested area.

Table 1 shows the herbicides registered for parthenium weed control and application rates. Before using any herbicide always read the label carefully. All herbicides must be applied strictly in accordance with the directions on the label.

Cropping areas—Controlling parthenium weed in cropland requires selective herbicide use and/or crop rotations. For further information on parthenium weed control in crops consult your local biosecurity officer.

Biological control

The combined effects of biological control agents reduced the density and vigour of parthenium weed and increased grass production.

There are currently a number of insect species and two rust pathogens that have been introduced to control parthenium weed—a selection of these are outlined below.

Epiblema strenuana is a moth introduced from Mexico established in all parthenium weed areas. The moth's larvae feed inside the stem, forming galls that stunt the plant's growth, reduce competitiveness and seed production.

Listronotus setosipennis is a stem-boring weevil from Argentina but is of limited success in reducing parthenium weed infestations.

Zygogramma bicolorata is a defoliating beetle from Mexico which is highly effective where present. It emerges in late spring and is active until autumn.

Smicronyx lutulentus (Mexico) lays eggs in the flower buds where the larvae feed on the seed heads.

Conotrachelus albocinereus (stem-galling weevil from Argentina) produces small galls and is still becoming established in Queensland.

Bucculatrix parthenica (leaf mining moth from Mexico) larvae feed on leaves, leaving clear windows in the leaf.

Carmentia ithacae is a stem boring moth from Mexico which is becoming established at favourable sites in the northern Central Highlands.

Puccinia abrupta is a winter rust from Mexico that infects and damages leaves and stems. It is currently established over a wide area from Clermont south. It requires a night temperature of less than 16 degrees and 5–6 hours of leaf wetness (dew). Sporadic outbreaks occur where weather conditions are suitable.

Puccinia melampodii is a summer rust from Mexico that weakens the plant by damaging the leaves over the summer growing season. It is currently established and spreading at a number of sites from north of Charters Towers to Injune in the south.

Manual control

Hand pulling of small areas is not recommended. There is a health hazard from allergic reactions and a danger that mature seeds will drop off and increase the area of infestation.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

Table 1 Herbicides registered for parthenium weed.

Herbicide	Rate	Situation	Comments
2,4-D amine 500 g/L	0.4 L/100 L	Land—industrial, pastures; rights-of-way	Spot spray
atrazine 500 g/L	3.6–6 L/ha	Fields and fallow	Boom spray
max 3 kg/ha/yr	6 L/ha	Land—industrial, commercial, non-agricultural, roadside, right-of-way	Boom spray
atrazine 900 g/kg	2–3.3 kg/ha	Fields and fallow	Boom spray
max 3 kg/ha/yr	3.3 kg/ha	Land—non-agricultural, commercial, industrial	Boom spray
2,4-D + picloram (Tordon 75-D)	125 ml/100 L	Land—commercial, industrial, pastures, right-of-way	Spot spray
	3 L/ha	Land—commercial, industrial, pastures, right-of-way	Boom spray
2,4-D ester[1]	.025 L/10 L	Land—non-agricultural, pastures	Rosette stage
glyphosate (450 g/L)	0.8–1.2 L/ha	Fields and fallow	Spot spray
metsulfuron methyl	5–7 g/ha	Fields and fallow	Seedlings only
	5 g/100 L	Land—commercial, industrial, pastures, rights-of-way	Spot spray
hexazinone	3.5 L/ha or 7 L/10 L/20 m^2	Land—commercial, industrial, pastures, rights-of-way	Boom spray or spot spray
dicamba (200 g/L)	0.7–2.8 L/ha or 0.1–0.19 L/100L	Grass pastures	Boom spray or spot spray
(500 g/L)	0.28–1.1 L/ha or 0.40–0.76 L/100L	Grass pastures	Boom spray or spot spray
(700 g/kg)	200–800 g/ha or 30–60 g/100 L	Grass pastures	Boom spray or spot spray

[1]Use restricted in some areas of Central Queensland

Notes The registered rates are for non-crop uses. Consult label for in-crop recommendations.
For power hand spray or knapsack use, spray plants to the point of runoff.

CS0564

Fact sheet

DECLARED CLASS 1 AND 2 PEST PLANT

Prickly pear

Opuntia, *Nopalea* and *Acanthocereus* spp.

The introduction and spread of prickly pears into Queensland and New South Wales is one of the greatest environmental invasions of modern times.

Prickly pears were introduced into pastoral districts in the 1840s. By 1900, over 4 million hectares in Queensland and New South Wales was infested by prickly pear. By 1925, the pest had invaded over 24 million hectares. Control costs were prohibitive and the only effective herbicide at the time was hazardous. This resulted in landholders abandoning large tracts of land.

Research for biological control agents commenced in 1912, and in 1914 cochineal insects were released to control one of the minor prickly pear species. Control of this minor prickly pear species by these introduced insects occurred within a few years.

The success of the cochineal insects led to renewed efforts against other types of prickly pear in the 1920s. These efforts resulted in the control of the major pest prickly pear by the moth *Cactoblastis cactorum*; by the mid-1930s, prickly pear was no longer a major problem.

Several prickly pear species have since remained as minor weeds.

Queensland Government

PP29 February 2012

Declaration details

Prickly pear (*Opuntia* spp.) is a declared Class 1 plant under the *Land Protection (Pest and Stock Route Management) Act 2002*. *O. ficus-indica* is not declared. *O. Stricta, O. aurantiaca, O. monacantha, O. tomentosa* and *O. streptacantha* species are Class 2 declared pest plants and all other species are declared Class 1.

Description and general information

'Prickly pear' is a general term used to describe some plants of the Cactaceae family. The term includes species of *Opuntia, Nopalea* and *Acanthocereus*. All of these plants originate in the Americas. The term 'prickly pear' relates to the fruit that is often spiny and pear-shaped. Plants are normally leafless succulent shrubs. Stems are divided into segments (pads or joints) that are flat and often incorrectly called leaves.

Young shoots have true leaves resembling small fleshy scales that fall off as the shoot matures.

Flowers are large, normally seen during spring and can be yellow, orange, red, pink, purple or white depending on the species. Prickly pear fruits vary between species and can be red, purple, orange, yellow or green.

Areoles (spots with clusters of spines) are found on both the pads (joints, segments) and fruit. In addition to spines, areoles often have clusters of sharp bristles (glochids) and tufts of fibre ('wool'). Each areole contains a growing point that can produce roots or shoots.

Life cycle

Prickly pears have several features that enable them to compete and become pests.

Prickly pears are drought resistant because of their succulent nature, their lack of leaves and their thick, tough skins. These features result in plants that use the majority of their internal tissues for water storage and their outer parts to reduce water loss and damage by grazing and browsing animals. They can remain vigorous in hot, dry conditions that cause most other plants to lose vigour or even die. Some species develop underground bulbs that enable the plant to resist fire and mechanical damage.

Prickly pears reproduce both sexually and asexually. Birds and other animals readily eat the many seeded fruits and deposit seeds in their droppings. Seeds have hard seed coats that allow them to survive heat and lack of water. Asexual reproduction (cloning) of prickly pears occurs when pads (joints, segments) or fruits located on the ground take root and produce shoots. Animals and floods move broken pads long distances. These pads can survive long periods of drought before weather conditions allow them to set roots.

Habitat and distribution

Prickly pears considered pests in Queensland are:

- Common pest pear (= *O. inermis*) — *Opuntia stricta* var. *stricta*
- Spiny pest pear (= *O. stricta*) — *Opuntia stricta* var. *dillenii*
- Tiger pear — *Opuntia aurantiaca*
- Drooping tree pear (= *O. monacantha*) — *Opuntia vulgaris*
- Velvety tree pear — *Opuntia tomentosa*
- Westwood pear — *Opuntia streptacantha*
- Devil's rope pear — *Opuntia imbricata*
- Coral cactus — *Opuntia cylindrica*
- Snake cactus X *O. imbricate* — *Opuntia fulgida*
- Sword pear — *Acanthocereus pentagonus*

Common pest pear (*Opuntia stricta* var. *stricta*)

This bushy, spreading plant grows up to 1.5 m high and forms large clumps. The stems are divided into oval, blue-green spineless pads 20 cm long and 10 cm wide. Areoles are in diagonal lines along the pads 2.5 cm to 5 cm apart and have a cushion of brown wool containing bristles but usually no spines. When spines occur they are stout, yellow and up to 4 cm long.

Common pest pear produces flowers that are 7.5 cm wide, bright lemon yellow and green at the base. The fruit is oval-shaped, has a deep cavity on one end and tapers at the other. Fruit is purple, 6 cm long and 3 cm wide, with carmine-coloured (dark red) seeds and a fleshy pulp.

Common pest pear is found as small to large clumps of varying density. The clumps are usually broken up by the action of *Cactoblastis cactorum*. Common pest pear occurs throughout most of central and southern Queensland and is still spreading westwards. It is often found along beaches and on offshore islands.

Spiny pest pear (*Opuntia stricta* var. *dillenii*)

This succulent shrub grows 1–2 m high. The stems are hairless and bluish-green or dull green. The stems are divided into pads up to 30 cm long, 15 cm wide and 1–2 cm thick. The areoles have tufts of short and finely barbed bristles accompanied by one or two yellow spines between 2 cm and 4 cm long. Small scale-like leaves are found on areoles of immature pads.

Spiny pest pear produces 6–8 cm wide flowers that are lemon yellow with green or pink markings on the back. The fruit is pear-shaped and about 4–6 cm long with a red-purple skin. The areoles located on fruits have fine, barbed bristles. The red flesh of fruits contains rounded seeds that are yellow or pale brown.

While this prickly pear once formed large-scale dense infestations, it is now found as small clumps or as scattered plants. These clumps are usually broken by the action of *Cactoblastis cactorum*. It is found in eastern central Queensland, the Burnett district, the Darling Downs and south-eastern Queensland.

Tiger pear (*Opuntia aurantiaca*)

This succulent low shrub with underground tubers usually grows 30–60 cm high. The stems are divided into very spiny, slightly flattened pads that are 1–30 cm long and 1–5 cm wide. The stems are dark green to purple and red in colour. The areoles have 3–7 brown barbed spines up to 4 cm long surrounded by tufts of short, fine bristles. The pads detach easily and are transported on the skins of animals. Small and scale-like leaves are found on areoles of immature pads.

Tiger pear produces 6 cm wide yellow flowers. The rarely formed fruits are pear-shaped and about 2.5 cm long. When ripe, they are red with purple markings.

Dense tiger pear forms an impenetrable spiny groundcover and is prevalent in southern Queensland but extends into central Queensland.

Drooping tree pear (*Opuntia vulgaris*)

This erect succulent shrub with fibrous roots grows up to 5 m high but is usually 2–3 m high. The branches are divided into glossy light green pads up to 45 cm long, 15 cm wide and 1.5 cm thick. The dark grey trunk grows up to 25 cm in diameter. Drooping tree pear gets its name because the upper segments tend to droop. The areoles on the older pads have 1–5 sharp spines about 5 cm long.

Small, scale-like leaves are found on areoles of very young pads that are quickly shed as the pad grows. Drooping tree pear produces yellow flowers that are 6 cm wide and have red markings on the back. The fruit is pear-shaped and 4–7 cm long with a green skin. The flesh of the fruit is red, pulpy and contains round seeds that are yellow or pale brown. The fruits have areoles with tufts of fine, barbed bristles.

Dense thickets result when drooping tree pear is allowed to grow freely. Small scattered infestations occur in the south-east corner of Queensland and in coastal northern Queensland.

Velvety tree pear (*Opuntia tomentosa*)

This tree-like plant forms a central woody trunk over 40 cm wide and grows up to 5 m high. The stems are divided into oblong pads that are dull green and velvety to touch due to the dense covering of short fine hairs. The pads are 15–35 cm long, 8–12 cm wide and 1.5–2 cm thick.

Young plants have 2–4 white or pale yellow spines located in the areoles with one spine reaching a length of 2.5 cm. The areoles usually become spineless as the plant matures. A more spiny variety does exist and has more than 50 spines in each areole on the trunk.

The flowers are a deep orange. The fruit is egg-shaped, about 5 cm long and 3 cm wide, and dull red. The top of the fruit is saucer-shaped with circular lines that meet in the centre and give the fruit a shrivelled appearance. The fruit produces many seeds within a reddish pulp.

Velvety tree pear is found predominantly throughout the brigalow belt of Queensland and is still extending its range. It is occasionally found as dense shrubs, but more usually as small clumps of trees or as trees scattered over the landscape.

Westwood pear, Cardona (*Opuntia streptacantha*)

Westwood pears are shrub-like or tree-like plants that form clumps by branching from the base. They are usually 2–4 m high. The stems are divided into almost circular dull green pads, 25–30 cm long and 15–20 cm wide. The areoles have white spines that vary in number and size when the plant matures.

Young pads have 2–5 white spines 1–2 cm long, accompanied by two hair-like spines 0.5 cm long in the lower part of the areole. Spines increase in number (up to 20) and size (5 cm long) in areoles along the trunk of the plant.

The flowers are yellow and fruits are barrel-shaped, 6 cm long and 5 cm wide with a flat top. The fruit has a purple skin and a rind that is 1 cm thick. Fruits contain red seeds buried in a dark red (carmine) pulp.

Westwood pear is found in eastern central Queensland as small clumps or as plants scattered over the landscape.

Devil's rope pear (*Opuntia imbricata*)

This open branching shrub grows 1.5–3 m high. The stems are divided into hairless, dull green, cylindrical pads that vary up to 37 cm in length and are 3.5–5 cm thick. The pads have a series of short raised ridges that give them a twined, rope-like appearance. The areoles are found on these ridges and produce 3–11 pale yellow or white spines, with the longest being 2.5 cm long. Papery sheaths cover these spines.

The flowers are a dull, red-purple colour and found at the ends of pads. The yellow fruit resembles a small, 5 cm wide custard apple and has a spineless areole at the top.

Devil's rope pear occurs in Queensland as a small infestation at Gladfield.

Coral cactus (*Opuntia cylindrica*)

Coral cactus grows as a branching shrub 1–1.5 m in high. The stems of coral cactus are divided into green cylinder-like pads that are fist-like and obtuse at their apex. Mature coral cactus pads widen, become distorted and wavy, and resemble a piece of coral. Areoles along the pads have a number of short white spines.

Coral cactus produces small (1–2 mm wide) scarlet flowers. The fruit is yellow-green and 2–5 cm wide.

Coral cactus has been located near Mount Isa, Longreach, Wyandra, Eulo and Hungerford but its potential spread includes all of far western Queensland.

Snake cactus (*Opuntia fulgida* X *O. imbricata*)

This open branching shrub grows 1–2 m high. The stems are divided into hairless, dull green, cylindrical pads that vary up to 20 cm in length and are 3.5–5 cm thick. The pads have a series of short raised ridges that give them a twined rope-like appearance. The areoles are found on the bottom of these ridges and produce 5–10 pale yellow to brown spines, with the longest being 3 cm long.

The flowers are light red to dark rose and commonly 5–7 cm wide. Snake cactus produces fruit that is yellow and 2–5 cm wide.

Snake cactus has been located near Longreach but its potential spread includes all of north-western Queensland.

Sword pear (*Acanthocereus pentagonus*)

This elongated branching shrub grows in clumps up to 4 m high. The stems are erect, up to 1.5 m long, 3–8 cm wide and divided into many joints. Sword pear stems are three-, four- or five-angled and resemble star-picket posts. The areoles are found on the edges of the joints and produce many white spines 1–4 cm long.

The flowers are white, funnel-shaped and 14–20 cm long. The flowers open at night between spring and summer. Sword pear produces bright red sphere-shaped fruits that are 5 cm in diameter. The fruit has a red pulp and black seeds.

Sword pear occurs in the Gogango area west of Rockhampton.

Control

Biological control

Investigations into biological control agents against prickly pears began in 1912. Over 150 insect species were studied throughout the world, with 52 species selected for transport to Queensland. Following intensive host specificity testing, 18 insects and one mite were released in Queensland. Nine insects and the mite remain established in Queensland. These species are:

- *Cactoblastis cactorum*, a stem-boring moth
- *Dactylopius ceylonicus*, a cochineal mealybug
- *Dactylopius opuntiae*, a cochineal mealybug
- *Dactylopius confusus*, a cochineal mealybug
- *Dactylopius tomentosus*, a cochineal mealybug
- *Dactylopius austrinus*, a cochineal mealybug
- *Chelinidea tabulata*, a cell-sucking bug
- *Tucumania tapiacola*, a stem-boring moth
- *Archlagocheirus funestus*, a stem-boring beetle
- *Tetranychus opuntiae*, prickly pear red spider mite.

These biological control agents continue to keep several prickly pears under control. It is important to remember not all the agents attack all prickly pears.

The most successful of these species were the moth *Cactoblastis cactorum* and five cochineal mealybugs—*Dactylopius ceylonicus, D. opuntiae, D. confusus, D. tomentosus* and *D. austrinus*. The other agents are still around but not in sufficient numbers to provide control.

Cactoblastis cactorum (cactoblastis moth)

Larvae of this moth were introduced from Argentina in 1925. Cactoblastis proved to be the most effective agent against the common and spiny pest pears, destroying massive infestations in Australia. Larvae keeps these two pest pears controlled to an acceptable level most of the time, although it is less effective in some coastal and far western areas.

The larvae collectively eat out the contents of the pads leaving empty pad skins and piles of mushy droppings. The orange and black larvae are occasionally observed on the outsides of pads. Cactoblastis also attacks most types of prickly pear but is not effective against them.

Dactylopius spp. (cochineal insects)

All female cochineal insects are small, sessile mealy bugs that spend their adult lives permanently attached to their host plants sucking plant juices. They are covered by a fine, white, waxy secretion and when crushed yield a carmine colouring. The adult males are small, free-flying insects that do not feed.

Dactylopius ceylonicus (monacantha cochineal, Argentine cochineal)

This South American mealy bug was released in 1914 and 1915 to control drooping tree pear. It destroyed the dense infestations existing at that time. It is specific to drooping tree pear and today remains the only effective biological control agent for drooping tree pear. This insect needs to be distributed manually.

Dactylopius opuntiae (prickly pear cochineal)

This mealy bug was introduced from Mexico and southern United States between 1920 and 1922. It is effective against common pest pear, spiny pest pear, velvety tree pear and Westwood pear and remains the main biological control agent against velvety tree pear and Westwood pear. This insect spreads slowly in nature and can be assisted manually.

Dactylopius confusus (prickly pear cochineal)

This mealy bug was introduced from Florida and released in 1933 against spiny pest pear. It remains effective against spiny pest pear in central Queensland but spreads slowly. This insect can be spread manually.

Dactylopius tomentosus (devil's rope pear cochineal)

This mealy bug was introduced from southern United States in 1925 and 1926. It is effective against devil's rope pear but works slowly.

Dactylopius austrinus (tiger pear cochineal)

This mealy bug was introduced from Argentina in 1932. It is specific to and effective against tiger pear. It rapidly reduces tiger pear populations but dies out in a paddock after the destruction of tiger pear. It needs to be reintroduced after tiger pear regrows.

Chelinidea tabulata (prickly pear bug)

This plant-sucking bug was introduced from Texas in 1921. It was effective against dense common pest pear before *Cactoblastis cactorum* was but is now relatively ineffective. This insect also attacks most other prickly pears. The adult is a pale brown bug up to 20 mm long that leaves characteristic round bleached spots on the surface of the cactus.

Tucumania tapiacola (prickly pear moth-borer)

This moth was introduced from Argentina in 1934 against tiger pear. Its solitary larvae feed internally and eat out tiger pear pads with limited effect. It has been observed attacking common pest pear and harrisia cactus.

Archlagocheirus funestus (tree pear beetle)

This stem-boring beetle was introduced from Mexico in 1935. It was effective against velvety tree pear and Westwood pear but has become rare since the dense stands of these prickly pears have gone.

Tetranychus opuntiae (prickly pear spider mite)

This mite was introduced from southern United States and Mexico in 1922. It was effective against common pest pear but is now rare and difficult to find. It causes distinctive scar tissue formation around areoles.

Distributing biological control agents

Cactoblastis

Cactoblastis can be spread manually by distributing eggs or larvae. Cactoblastis moths lay chains of eggs (eggsticks) on prickly pear pads from January–February and September–November. The eggsticks are distinguished from spines by their curved appearance.

1. Collect the fragile eggsticks carefully.
2. Glue single eggsticks to small pieces of paper using a starch-based adhesive.
3. Pin the egg papers to prickly pear pads. (Eggs take up to one month to hatch.)
4. Collect pads or plants in which larvae are obviously still active.
5. At a release site place all the collected plant material in a small part of the infestation.
6. Subsequent generations of moths will disperse through the infestation.
7. Follow up the biological control with either herbicide or mechanical treatment.

Cochineals

Because several cochineal insects affect some prickly pears and not others, it is essential to know what prickly pear you wish to control.

1. Identify your prickly pear type.
2. Find the same prickly pear type which is being attacked by a cochineal.
3. Collect pads of the prickly pear with the insects.
4. Place affected pads against unaffected prickly pears at the release site.
5. Follow up the biological control with either herbicide or mechanical treatment.

Tiger pear cochineal

Tiger pear cochineal is easy to multiply quickly after collection.

1. Carefully collect a reasonable quantity of unaffected tiger pear in a container (box or bucket).
2. Place a few pieces of cochineal-affected tiger pear into the same container.
3. Cover the container with a cloth and store under cover for a few weeks.
4. Check the cactus occasionally.
5. When most of the tiger pear in the container has cochineal, it is ready to distribute.
6. At the release site place affected pads against unaffected prickly pears.
7. Follow up the biological control with either herbicide or mechanical treatment.

Note: It is best to multiply tiger pear cochineal before release.

Mechanical control

Mechanical control using machinery is difficult because prickly pear pads can easily re-establish. A hot fire is an effective control method for dense prickly pear infestations. Before burning, consult Biosecurity Queensland to see if this practice is suitable for your pasture and land management practices.

Herbicide control

Herbicide options available for the control of prickly pears in Queensland are shown in Table 1.

Landholders and contractors should check if the property is in a hazardous area as defined in the *Agricultural Chemicals Distribution Control Act 1966* prior to spraying.

Further information

Further information is available from your local government office or from your local biosecurity officer. Contact details are available through 13 25 23.

Table 1 Herbicides registered for the control of prickly pears

Pest name	Situation	Herbicide	Rate	Method
Common prickly pear	Agricultural land—non-crop	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	
	Forests—timber production	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
			3 L/100 L or 1 L/75 L diesel	Foliar
	Land—commercial/industrial/public	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
			3 L/100 L or 1 L/75 L diesel	Foliar
	Land—non-agricultural	Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
	Land—rights of way	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
			3 L/100 L or 1 L/75 L diesel	Foliar
	Pastures	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
			3 L/100 L or 1 L/75 L diesel	Foliar
Coral cactus	Agricultural land—non-crop	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
	Land—commercial/industrial	Triclopyr (240 g/L) + picloram (120 g/L)	See permit PER10550 (expires 30 June 2013)	
		Triclopyr (300 g/L) + picloram (100 g/L)		
		Triclopyr (300 g/L) + picloram (100 g/L) + aminopyralid (8 g/L)	See permit PER0532 (expires 30 June 2013)	
	Forests—timber production	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump

Continued

Pest name	Situation	Herbicide	Rate	Method
Coral cactus	Land—commercial/ industrial/public	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
	Land—rights of way	Triclopyr (300 g/L) + picloram (100 g/L)	See permit PER10550 (expires 30 June 2013)	
		Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L) + aminopyralid (8 g/L)	See permit PER0532 (expires 30 June 2013)	
	Pastures	Triclopyr (300 g/L) + picloram (100 g/L)	See permit PER10550 (expires 30 June 2013)	
		Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L) + aminopyralid (8 g/L)	See permit PER10532 (expires 30 June 2013)	
Tiger pear	Agricultural land—non-crop	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	
	Forests—timber production	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
			3 L/100 L or 1 L/75 L diesel	Foliar
	Land—commercial/ industrial/public	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
			3 L/100 L or 1 L/75 L diesel	Foliar
	Land—non-agricultural	Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
	Land—rights of way	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
			3 L/100 L or 1 L/75 L diesel	Foliar
	Pastures	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	3 L/100 L or 0.8 L/60 L diesel	Basal bark/cut stump
			3 L/100 L or 1 L/75 L diesel	Foliar
Drooping tree pear	Agricultural land—non-crop	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (600 g/L)	0.8 L/60 L diesel	
	Forests—timber production	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	0.8 L/60 L diesel	Basal bark/cut stump
			1 L/75 L diesel	Foliar
	Land—around buildings	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
	Land—commercial/ industrial/public	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
		Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	0.8 L/60 L diesel	Basal bark/cut stump
			1 L/75 L diesel	Foliar

Continued

Pest name	Situation	Herbicide	Rate	Method
Drooping tree pear	Land—non-agricultural	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	0.8 L/60 L diesel	Basal bark/cut stump
	Land—rights of way	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
		Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	0.8 L/60 L diesel	Basal bark/cut stump
			1 L/75 L diesel	Foliar
	Pastures	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
		Triclopyr (300 g/L) + picloram (100 g/L)	0.5 L/100 L	
		Triclopyr (600 g/L)	0.8 L/60 L diesel	Basal bark/cut stump
			1 L/75 L diesel	Foliar
Velvety tree pear	Agricultural land—non-crop	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
	Forests—timber production	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
	Land—around buildings	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
Velvety tree pear	Land—commercial/industrial/public	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
		Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
	Land—non-agricultural	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
	Land—rights of way	Amitrole (250 g/L) + ammonium thiocyanate (220 g/L)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	
		Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
	Pastures	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump
Spiny pest pear Westwood pear Devil's rope pear Snake cactus	Agricultural land—non-crop Forests—timber production Land—commercial/industrial/public Land—rights of way Pastures	Triclopyr (240 g/L) + picloram (120 g/L)	1 L/60 L diesel	Basal bark/cut stump

Fact sheets are available from Department of Employment, Economic Development and Innovation (DEEDI) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DEEDI does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

CS1027 02/12

Fact sheet

DECLARED CLASS 2 PEST PLANT

Rubber vine

Cryptostegia grandiflora

Rubber vine's ability to quickly spread and colonise areas makes it a threat to many areas of northern Australia. Due to this ability, rubber vine is listed as a Weed of National Significance.

Rubber vine generally invades waterways first, where the seeds germinate in moist silt layers after rain. The plant smothers riparian vegetation and forms dense, sometimes impenetrable, thickets.

This decreases biodiversity and prevents access to both stock and native animals. It also creates habitat for feral animals. Infestations expand outward from waterways, hillsides and pastures, resulting in loss of grazing land and increased difficulty in mustering stock.

Rubber vine is poisonous to stock, though seldom eaten. Most deaths due to rubber vine occur after stock have been stressed, or when other feed is scarce.

PP11 January 2011

Queensland Government

Declaration details

Rubber vine is a declared Class 2 plant under the *Land Protection (Pest and Stock Route Management) Act 2002*. Declaration requires landholders to control declared pests on the land and waters under their control. A local government may serve a notice upon a landholder requiring control of declared pests.

Description and general information

Rubber vine is a vigorous climber with twining, whip-like shoots that can grow unsupported as an untidy, multi-stemmed shrub 1–2 m high, or it can scramble up to 30 m high in trees. The stems, leaves and unripe pods exude a white, milky sap when broken or cut.

Leaves are dark green and somewhat glossy, 6–10 cm long, 3–5 cm wide, and in opposite pairs.

Flowers are large and showy, with five white to light purple petals arranged in a funnel shape.

The seed pods are rigid and grow in pairs at the end of a short stalk. The pods are 10–12 cm long, 3–4 cm wide and each can contain up to 450 brown seeds. Each seed has a tuft of long, white, silky hairs, which enable easy dispersal by wind and water.

Life cycle

Rubber vine flowers at any time of year if sufficient moisture is available. Usually, June and July are the only non-flowering months. Plant stem diameter must be approximately 20 mm before flowering can occur.

Seed pod formation occurs from spring to late autumn, with peak seed production corresponding to maximum flowering. Eventually, pods dry out and split open, with pod-splitting occurring approximately 200 days after formation.

Seeds are scattered by wind, but also carried downstream by water. Approximately 95% of seed is viable, although germination requires favourable temperature and soil moisture conditions.

Habitat and distribution

Rubber vine is native to Madagascar, but is now widely distributed throughout tropical and subtropical regions of the world.

The plant was introduced to Australia as an ornamental shrub in 1875 or earlier, and was popular in north Queensland mining settlements due to its luxuriant growth even under harsh conditions. Weedy infestations were recorded around Charters Towers early this century.

Rubber vine prefers areas where annual rainfall is 400–1400 mm, and is well adapted to a monsoonal climate.

Infestations of rubber vine are now found throughout river systems of southern Cape York and the Gulf of Carpentaria, south along the coast to the Burnett River, and isolated infestations occur as far south as Gatton and as far west as the Northern Territory border.

Infestations are common throughout central Queensland, while in western Queensland there are infestations in the Mount Isa, Longreach and Aramac areas. Isolated infestations have been reported in Western Australia.

Control

Effective control of rubber vine can be achieved by a number of methods, alone or in combination depending on the situation and the severity of infestation. All areas treated must be periodically checked and any regrowth treated or the initial treatment efforts will be wasted.

Management strategies

Rubber vine seed is most commonly spread by wind and running water.

It is thus difficult to prevent seed coming onto uninfested land if there is rubber vine anywhere in the area. Your goal should be to prevent rubber vine from establishing and forming dense infestations. It is essential to regularly inspect all areas of your property, paying particular attention to creeks and gullies.

This is most important where prevailing winds are known to blow from infested areas, or where infestations occur upstream.

Any isolated plants located should be treated promptly.

All control of rubber vine will require follow-up treatments to keep your property clean. As rubber vine spreads quickly, small infestations should be controlled first to prevent them from becoming major problem areas. Dense infestations are difficult and costly to treat.

Follow-up treatment must be budgeted for within the overall control program. Techniques need to be integrated for successful rubber vine management. Consideration should be given to coordinating control over a catchment area.

Five suggested strategies for controlling rubber vine in scattered, medium, and dense infestations are outlined in Table 1 (overleaf).

Fire

Rubber vine infestations can be very effectively controlled by burning. Preparing and managing fuel load prior to burning, and following up in a timely manner after the fires, are critical to the overall success of the program.

It is recommended that you perform two successive annual burns. The first fire will open up the infestation to increase grass growth (fuel load) while killing rubber vine plants. The second fire will clean up the regrowth that occurs after the first fire.

An appropriate fire regime is an effective tool for managing rubber vine over the long term, as well as being an effective follow-up to other control methods.

For further information contact 13 25 23.

Biological control

Two biological control agents are successfully established, and their impact depends on abundance. Both agents cause abnormal defoliation, creating an 'energy sink', which appears to reduce seed production. These agents usually do not kill established rubber vine plants.

Diseases

Rubber vine rust (*Maravalia cryptostegiae)* is established over a wide area. Yellow spores form under the leaves and are spread mainly by the wind.

It is most active over summer, abundance being directly related to leaf wetness, which is dependent on rainfall and dew. Over summer, a generation is completed every seven days. Rust activity is reduced over the dry season.

Continued heavy infection causes defoliation, appears to reduce seed production, can kill small seedlings and causes dieback of the whip-like stems. Established plants are not killed.

Insects

Also established is the moth *Euclasta whalleyi*, whose larvae are leaf feeders. Observation indicates the moth prefers stressed plants, either from limited soil moisture or high levels of rust infection.

The moth's period of activity is the dry season. A native fly parasite and a disease can reduce the localised abundance of the *Euclasta* larvae.

The larvae are tapered at both ends, grow up to 30 mm long, and are grey-brown with orange dots along their sides. Fine silken threads and black, bead-like droppings are often found near the larval feeding damage.

The creamy-brown moths are active at night and rest at a 45˚ angle from a surface, with their wings folded. The life cycle from egg to adult takes 21–28 days.

Defoliation reduces the smothering effect on other vegetation and causes an increase in leaf litter and promotes increased grass growth amongst rubber vine, increasing fuel loads required for fire management. Decreased flower and pod production should reduce the ability of rubber vine to spread.

Biological control is also important because it impacts on other control methods.

Mechanical control

Several mechanical techniques are effective in controlling rubber vine. The type of infestation will determine the technique required.

- Scattered or medium-density infestations: Where possible, repeated slashing close to ground level is recommended.
- Dense infestations: During winter, stick-raking or blade-ploughing reduces the bulk of the infestation. Pasture should be sown and windrows burned to kill residual seed. Follow-up treatment is essential. It is important to comply with the relevant state and/or local government native vegetation legislation, and it should be noted that causing even accidental death of vegetation can be a breach of this legislation.

Herbicide control

Herbicides recommended for use on rubber vine are listed in Table 2 (overleaf). Preference ratings (taking account of effectiveness and cost) are shown.

Aerial application

Three herbicides are currently registered for aerial application (refer to Table 2). Two of these are foliar herbicides and the other is a soil-applied herbicide. As a result, the necessary conditions that apply to foliar and soil applications is also applicable to the respective chemical when aerially applied.

People considering aerial application are advised to contact 13 25 23 for current advice on use of this technique.

Foliar spray

The following points should be followed carefully:

- There must be little to no rust present as it affects the health of the plant and its ability to take chemical up through its leaves.
- It is critical that plants be actively growing and NOT water-stressed, yellowing or bearing pods.

- A wetting agent should be used with foliar herbicides.
- Thoroughly spray bushes to the point of run-off, wetting every leaf.
- Avoid spraying when hot and dry (e.g. over 35 °C), or when windy—especially with Agricrop Rubber Vine Spray.
- Foliar spraying is most effective on plants less than 2 m high; large plants with a stem diameter greater than 8 cm may not be killed.

Basal bark spray

This method gives a high level of control although it is not as effective on multi-stemmed plants as it is difficult to spray each stem completely around the base.

Thoroughly spray around the base of the plant to a height of 20–100 cm above ground level, spraying higher on larger plants.

Optimum results are attained when the plant is actively growing.

Cut stump treatment

This is the most successful method of chemical control, but also the most labour intensive. The following points should be followed carefully:

- Cut the stem off as close to the ground (within 15 cm) as possible; for smaller plants use a machete or similar; larger plants may require a chainsaw.
- Make sure the cut is horizontal.
- Immediately spray or swab the cut surface.
- A cost-effective method for scattered to medium-density infestations is the use of a brush-cutter.

Soil application

Because of the high risk of killing non-target vegetation, including trees and pasture plants, soil-applied herbicides play a role in controlling rubber vine only in specific situations.

It is important to comply with the relevant state and/or local government native vegetation legislation, and it should be noted that causing even accidental death of vegetation can be a breach of this legislation.

The following points should be followed carefully:

- Do not use residual herbicides within a distance of two or three times the height of desirable trees.
- Do not use Graslan along waterways or land with greater than a 20° slope.
- A minimum of 50–80 mm of rainfall is required before residual herbicides are taken up by the plant.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

Figure 1 Rubber vine containment line and distribution map

Table 1 Suggested strategies for the control of rubber vine

Situation	Initial treatment	Follow-up	Comments
Scattered infestations	Basal bark/ cut stump	Follow-up with basal bark/cut stump as necessary	Cut stump method preferred where possible.
	Foliar spray	Follow-up basal bark/cut stump/ foliar spray as necessary	Only foliar spray when there is nil to little rust on the leaves of the plants.
	Fire	Follow-up basal bark/cut stump/ foliar spray as necessary	For scattered infestations usually recommended only if herbicides not desired, or if have other weeds can be controlled by fire or if fire is utilised to improve pastures.
	Repeated slashing	As above	
Medium infestations	Foliar spray	Treat regrowth, seedlings with basal bark/cut stump/foliar spray	Fire and follow-up with basal bark/cut stump/ foliar spray as necessary.
	Fire	Fire 1 year later and follow-up basal bark/cut stump/foliar spray as necessary	If fuel load is sufficient. CAUTION: There are some native tree species which are susceptible to fire. Check before burning.
	Repeated slashing	As above	
Dense infestations—previously cleared areas	Stick rake or blade plough	Sow pasture ▸ basal bark/foliar spray ▸ fire and basal bark/cut stump/foliar spray as necessary	First treatment clears bulk of rubber vine and kills roots; any regrowth or seedlings can then be treated; when grass growth allows fuel build up, fire used as control and individual plants later treated.
	Fire	Fire 1 year later and follow-up basal bark/cut stump/foliar spray as necessary	If fuel load is sufficient. CAUTION: There are some native tree species which are susceptible to fire. Check before burning.
	Aerial spray	Fire 1–2 years later OR follow-up with basal bark spray	Bulk of rubber vine killed with aerial spray; allow build up of fuel for fire or treat remaining plants with basal bark spray. Contact 13 25 23 before use of method.
	Graslan		Where situation and soil type are suitable.
Dense infestations—along creeks and rivers	Basal bark/ cut stump	Fire OR basal bark/cut stump/ foliar spray	When bulk of rubber vine killed, allow fuel build up for fire or treat remaining plants individually.
	Fire and sow pasture	Fire 1 year later and follow-up basal bark/cut stump/foliar spray as necessary	If there is a sufficient fuel load to carry a fire, it can open up dense infestations. CAUTION: There are some native tree species which are susceptible to fire. Check before burning.

PR11–5580

Table 2 Herbicides registered for the control of rubber vine

Situation	Herbicide	Pref. *	Rate	Optimum stage and time	Comments
1. Foliar (overall) spray (ground)	Triclopyr + picloram (Grazon DS, Grass-up, etc.)	1	0.35–0.5 L /100 L water	During active growth	May damage pasture legumes.
	Dicamba (200 g/L) + 2,4-D Ester 800 g/L	1	0.35–0.7 L /100 L water + 175 ml 2, 4-D Ester	As above	As above. Apply in autumn during active growth.
	Metsulfuron methyl (e.g. Brush-off®, Brushkiller™ 600, etc.)	1	15 g/100 L water	As above	Wetting agent is critical. Complete coverage is essential. May damage pasture legumes.
	2,4 D + picloram (Tordon 75-D)	2	1.3 L/100 L water	As above	Thoroughly wet leaves and soil around base of plant.
	2,4-D Ester (Agricrop Rubber Vine Spray)	3	0.5 L/100 L water + activator	As above	May damage pasture legumes; less effective than other treatments, but also much cheaper.
2. Basal bark	2,4-D Ester (Agricrop Rubber vine spray)	1	2.5 L/100 L diesel	Plants actively growing	Thoroughly spray around base of plant.
	Triclopyr + picloram (Access)	1	1 L/60 L diesel	Anytime	
	Triclopyr (eg Garlon 600, Invader 600®, etc.)	1	1 L/60 L diesel	Anytime	
3. Cut stump	2,4-D Ester (Agricrop Rubber Vine Spray)	1	2.5 L/100 L diesel	Anytime	Immediately swab/spray cut surface and base of stem.
	Triclopyr + picloram (Access)	1	1 L/60 L diesel	As above	As above.
	Triclopyr (e.g. Garlon 600, Invader 600®, etc.)	1	1 L/60 L diesel	Anytime	
	2,4 D + picloram (Tordon 75-D)	2	1.3 L/100 L water	As above	As above.
	2,4-D Amine (500 g/L)	2	2 L/100 L water	As above	As above. Less effective than other treatments. Repeat applications may be required.
4. Soil application#	Hexazinone# (Bobcat® SL, Velpar® L)	1	1–4 ml/spot or 6 ml/vine or bush	Prior to rain	See warning below.# Must place spots around bush. Less effective on sandy soils.
	Tebuthiuron# (Graslan)	1	1.5 g/m2	As above	As above; application by hand or backpack spreader.
5. Aerial application	Triclopyr + picloram (Grazon DS, Grass-up, etc.)	1	3–5 L/ha	Plants actively growing	Before aerial application contact 13 25 23.
	Tebuthiuron# (Graslan)	1	7.5–15 kg/ha	Prior to rain	As above.
	2,4-D Ester (Agricrop Rubber Vine Spray)	3	0.5 L/100 L water + activator	Plants actively growing	As above.

* Preference rating— takes account of effectiveness and cost

WARNING: Soil testing is highly recommended prior to application of these herbicides, as rate and efficacy are dependant on soil type.
DO NOT USE SOIL APPLIED HERBICIDES (HEXAZINONE AND GRASLAN) WITHIN A DISTANCE OF TWO TO THREE TIMES THE HEIGHT OF DESIRABLE TREES. DO NOT USE GRASLAN NEAR WATERWAYS OR LAND WITH GREATER THAN A 20° SLOPE.

Appendix C. Management schedule

Appendix D. Management strategies

Management strategies – weeds

Construction

Element / issue	Introduction or spread of weed species.

Performance objectives	Management strategies	Performance criteria	Monitoring	Corrective action
Weeds				
To prevent the spread of weeds.	Develop and implement a Weed Management Plan with reference to Arrow's *Pest Management Program, 2012* which adopts principles developed in alliance with the Australian Weeds Strategy (C112).	Distribution of weed species within the ROW.	Monitoring of weed infestations within disturbed areas should occur monthly during construction and then annually for a period of two years following construction. Following the two year period, the frequency of monitoring should be reconsidered dependent on the success of control measures and the level of infestations.	Implement measures (e.g. controlled spraying or pulling) to remove invasive species, should weed species associated with project activities be detected.
Vehicles/plant and equipment				
To prevent the spread of weeds.	▪ All vehicles and plant must be washed down by vehicle operators consistent with the *Queensland Checklist for Cleandown Procedures* (DNR 2000) and certified weed free by trained personnel. ▪ Trained personnel will assess vehicles, plant and equipment following cleaning and issue certification. A register will be	Prevent increases in the distribution of weeds along the ROW.	Monitor certification of vehicles, plant and equipment cleaned.	Vehicles, plant and equipment failing an inspection will be washed down and re-inspected.

Performance objectives	Management strategies	Performance criteria	Monitoring	Corrective action
	maintained of vehicles, plant and equipment cleaned. ▪ Locations for washdown facilities will be identified prior to construction. ▪ Fixed washdown facilities will be constructed in accordance with Queensland Guidelines for the Construction of Vehicle and Machinery Wash-down Facilities, 2000.			
Clear and grade				
To prevent the spread of weeds.	▪ Prior to the clear and grade, a weed inspection will be undertaken and a spraying program implemented. ▪ Stockpiled topsoil and subsoil will be reused in the same locality from which they were extracted to avoid the spread of weeds.	Weeds controlled prior to clear and grade	Weeds sprayed and eradicated. Monitor certification of vehicles, plant and equipment cleaned.	Re-spray or remove weeds. Vehicles, plant and equipment failing an inspection will be washed down and re-inspected.

Auditing	▪ Audits to be conducted in accordance with Appendix A.
Reporting	▪ Maintain a Washdown Register of vehicle, plant and equipment declared freed of weeds and copies of all washdown certificates. ▪ Maintain records of weed spraying and or removal. ▪ Maintain records of weed inspections, ▪ Maintain records of complaints in Complaints Register. ▪ Maintain records of any non-compliances, incidents or accidents.
Responsible person(s)	▪ Environmental Officer.
Associated documentation	▪ Arrow Pest Management Program, 2012

	▪ *Queensland Checklist for Cleandown Procedures* (DNR 2000) ▪ *Queensland Guidelines for the Construction of Vehicle and Machinery Washdown Facilities* (DNR 2000) ▪ Weed information sheets

Operations

Element / issue	*Introduction or spread of weed species.*

Performance objectives	Management strategies	Performance criteria	Monitoring	Corrective action
To prevent the spread of weeds along the pipeline easement.	Implement annual weed treatment program along the ROW where weed infestations are identified. Typically, this is implemented in conjunction with landholder spraying and weed control programs. Ensure equipment and vehicles are cleaned in designated wash-down sites before leaving weed-infested areas or entering weed-free areas.	Prevent changes in the distribution of weeds along the ROW	Annual monitoring of the pipeline easement to confirm the effectiveness of weed control measures for a period of two years following construction. Following the two year period, the frequency of monitoring should be reconsidered dependent on the success of control measures and the level of infestations.	Implement measures (e.g. controlled spraying or physical removal) to remove invasive species, should weeds be detected.

Auditing	▪ Audits to be conducted in accordance with Appendix A. ▪ Independent audit every two years.
Reporting	▪ Complete easement inspection checklists to monitor control of weeds along the pipeline easement. ▪ Maintain a Washdown Register of vehicle, plant and equipment declared freed of weeds and copies of all washdown certificates. ▪ Maintain records of any non-compliances, incidents or accidents. ▪ Annual Return.
Responsible person(s)	▪ Environmental Officer.

	▪ Operations Manager.
Associated documentation	▪ As required for operations activities, for example: – *Land Protection (Pest and Stock Route Management) Act, 2002* – Arrow Pest Management Program, 2012 – *Queensland Checklist for Cleandown Procedures* (DNR 2000) – Weed information sheets – *Queensland Guidelines for the Construction of Vehicle and Machinery Washdown Facilities* (DNR 2000).

Appendix E. Monitoring schedule