WEEDS OF NATIONAL SIGNIFICANCE

Parthenium weed

(*Parthenium hysterophorus* L.)

strategic plan 2012–17

This publication is produced as part of the Weeds of National Significance initiative, a joint initiative between the Commonwealth of Australia and each of the Australian states and territories.

ISBN 978-1-921575-91-4 (online)

Published by the Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.

An unpublished draft of the revised strategic plan has guided national coordination of this Weed of National Significance for the past two years. Before publishing the revised plan, the Australian Weeds Committee altered it because some actions had been completed, and then agreed to include a uniform monitoring, evaluation, reporting and improvement (MERI) template for all phase-3 Weeds of National Significance.

Supporting information about the Australian Weeds Strategy, Weeds of National Significance and progress to date may be found at www.weeds.org.au, where links and downloads provide contact details for all species and copies of the strategy. Comments and constructive criticism are welcome as an aid to improving the process and future revisions of this strategy.

This publication (and any material sourced from it) should be attributed as:

Australian Weeds Committee 2012, *Pathenium (*Parthenium hysterophorus *L.) strategic plan 2012–17*, Weeds of National Significance*,* Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.

Inquiries should be addressed to:
Secretariat
Australian Weeds Committee
GPO Box 858
CANBERRA ACT 2601

Email: awc@daff.gov.au
Web: www.weeds.org.au

Copies of this publication are available from the Secretariat or at www.weeds.org.au/wons.

Contents

Acknowledgements

Principal author

Peter Austin	National Coordinator (Parthenium weed and Rubber vine) Department of Agriculture, Fisheries and Forestry, Queensland

National Parthenium Weed Management Group

Steve Adkins	University of Queensland and Chair of the Parthenium Study Group
Philip Blackmore	Department of Primary Industries, New South Wales
Nora Brandli	Regional Weeds and Pest Animal Coordinator, Burnett Mary Regional Group for Natural Resources Management, Queensland,
David Bridgeman	Landholder at Clermont, Parthenium Health Group
John Chamberlain	Community member and Deputy Chair
Natalie Dearden	Community member, Tannum Sands, Weed Seed Spread
Kunjithapatham Dhileepan	Senior Scientist (Entomologist) Department of Agriculture, Fisheries and Forestry, Queensland
Noeleen Ferguson	Landholder at Charters Towers, representing North Queensland Dry Tropics
Graham Hardwick	Department of Agriculture, Fisheries and Forestry, Queensland
Neil Judd	Chief Executive Officer, South West Natural Resources Management Group, Queensland
Bruce Lord	Community Partnerships Manager—South East Queensland Catchments Ltd
Darren Marshall	Regional Weeds and Pest Animal Coordinator, Queensland Murray Darling Committee Inc
Carli McConnel	Landholder at Esk, representing Agforce
John Murphy	Landholder at Kingaroy, representing Australian Grain Harvesters Association and Chair
Mark Tarrant	Department of Natural Resources, Environment, the Arts and Sport, Northern Territory
Eric Williamson	Quality Service Manager, Graincorp

Summary

Parthenium weed (*Parthenium hysterophorus* L.) is an annual or short-lived perennial herb that colonises disturbed sites, degrades natural ecosystems and can produce serious allergic reactions in people. It is a major invasive weed in Queensland, with the potential to spread to all medium-to-low rainfall rangelands, low rainfall channel country and summer cropping areas. It has major impacts on pasture and cropping industries, with estimated losses of $109 million per year for Queensland pastoralists.

Parthenium weed poses a potential risk to most grazing and cropping areas in eastern and northern Australia. Currently, large well-established (or core) infestations are found in central Queensland, with smaller outbreaks in the south and west of the state. There are sporadic occurrences in northern and central New South Wales, Northern Territory and Western Australia.

This strategy has been revised in consultation with representatives from local and state governments, industry bodies, natural resource management groups and community groups, and has considered the achievements from previous programs. The strategy documents the commitments of these stakeholders and provides a clear framework for the coordinated management of parthenium weed throughout Australia.

Major challenges are raising awareness of parthenium weed; reducing the spread of weed seed via vehicles, produce and livestock; further improving integrated controls that support economically feasible management practices; supporting early detection and management of natural spread of the weed in buffer zones; and coordinating management of parthenium weed at national, state and regional levels.

This strategy has three goals and associated objectives:

1 Prevent new infestations from establishing
   - Establish protocols to reduce the movement and spread of parthenium weed.
   - Detect and record infestations through a surveying and mapping program.
   - Eradicate new infestations.
   - Use compliance as a management tool.

2 Strategically manage existing infestations
   - Maintain strategic containment programs.
   - Implement best-practice parthenium weed management.
   - Develop and implement a targeted communication program.
   - Investigate the impacts of parthenium weed in a changing climate.

3 Increase landholder capability and willingness to manage parthenium weed
   - Increase stakeholders' commitment to parthenium weed management.
   - Manage the implementation of the strategy.
   - Monitor the implementation of the strategy.
   - Develop cooperative management frameworks to deliver strategic objectives.

Vision

Parthenium weed is confined to core infestation areas and its impacts are minimised.

1 The challenge

Parthenium weed (*Parthenium hysterophorus* L.*)* was first introduced to Queensland 55 years ago. It matures rapidly and produces large numbers of seeds that are easily transported by vehicles, machinery, animals, fodder, pasture seed, stock-feed and water. In a short period, it spread from isolated outbreaks to establish core infestations across the central highlands of Queensland, with incursions into New South Wales and the Northern Territory. It has the potential to expand much further across northern and eastern Australia.

Parthenium weed causes estimated losses of $109 million per year if there is no control (Adamson 1996). It is estimated to affect cropping systems to the value of $10 million per year if no control is undertaken, including a $4 million impact to sunflower crops from the effects of Tobacco streak virus, which parthenium hosts. Significant costs are incurred controlling roadside infestations and in eliminating outlier infestations.

The environmental and social costs of parthenium weed have not been fully quantified; however, in Queensland, it could impact significantly on the biodiversity of the Einasleigh Uplands bioregion and the central highlands. Another important issue is that direct or indirect contact with any part of the plant or its pollen can produce serious allergic reactions including dermatitis, hay fever and asthma. This has a detrimental effect on the physical, social and economic quality of life for individuals and, ultimately, the community. Research has identified that those communities where the weed is established suffer considerably higher rates of parthenium sensitivity and considerably higher allergy rates. Subsequently, some landholders are reluctant to treat parthenium weed for fear of allergic reactions.

While the greatest impacts to date have been on grazing land and cropping areas in the central highlands of Queensland, parthenium weed has the potential to become a major weed on suitable soils across northern and eastern Australia. Further, inherent with the continuing spread of parthenium is an increased health risk to people. To prevent this from happening, it is imperative to contain parthenium weed within its current distribution, to eradicate it where possible, and to raise awareness and commitment to its control.

Progress has been made on the management of parthenium weed through the use of selective herbicides, improved grazing management, tillage and the introduction of biological control agents. Nationally, the challenge is to establish detection, eradication and monitoring procedures, and minimise the inadvertent spread of parthenium weed via vehicles, machinery, fodder and stock from core infestations.

In Queensland, the emphasis is to improve integrated control, including the effectiveness of biocontrol agents and economically feasible management practices that complement biocontrol. Management practices aimed at preventing further spread will be to no avail unless the opportunities for the establishment of new parthenium infestations in clean areas are radically reduced. Unless effective and efficient management is implemented and maintained, parthenium weed will continue to impact adversely on agriculture, human health and the environment.

Implementation of the Parthenium Weed Strategic Plan 2012–17 aims to contain the spread of parthenium weed in Australia and minimise the impact of established infestations.

2 Background

Parthenium weed tends to colonise areas with poor ground cover and exposed soil, such as fallow wastelands, roadsides and overgrazed pastures, often on fertile clay soils. It is generally much less abundant in undisturbed vegetation or in vigorous pasture, and there is a marked inverse relationship between parthenium density and existing plant cover and competition. Parthenium weed currently infests over 8 million hectares of central Queensland but has the potential to infest all medium-to-low rainfall rangelands, low rainfall channel country and summer cropping areas across Australia.

Parthenium weed is the only member of the genus *Parthenium*, family Asteraceae, presently in Australia. It is sometimes confused with a number of other introduced weeds from the Asteraceae family, including seedlings of cobbler's pegs (*Bidens subalternans*), flowers of bishop's weed (*Ammi majus*) and hemlock (*Conium maculatum*), and the ragweeds (*Ambrosia* spp.).

Parthenium weed is known by a number of common names including congress grass, false ragweed, star weed, carrot weed and bastard feverfew, depending on the country infested.

Parthenium weed

2.1 The biology of parthenium weed

Parthenium weed is an annual or short-lived perennial, growing up to 2 metres tall.

Several aspects of the ecology of parthenium weed contribute to its success, including the production of large numbers of seeds, the ability to form large and persistent soil seed banks, the longevity of the seeds when buried, rapid germination and emergence rates, and a seed dormancy mechanism. These attributes facilitate the species' persistence in seasonally dry habitats.

Parthenium weed flowers

As parthenium weed does not reproduce vegetatively, the only method of reproduction and dispersal is by seeds (Figure 1). Although wind-dispersal is limited, dispersal of seeds in flowing water is much more significant. Most long-distance dispersal of seeds is by vehicles and farm machinery, as evidenced by the major spread of parthenium along roads and the large numbers of seeds found in wash-down slurry pits. A period of drought followed by rain provides ideal conditions for germination. Drought reduces pasture cover (competition) and increased movement of stock and stock fodder also helps to spread the seeds. In particular, heavy rain after drought is advantageous to the weed because floodwater disperses the seed and mud allows the seed to stick to vehicles.

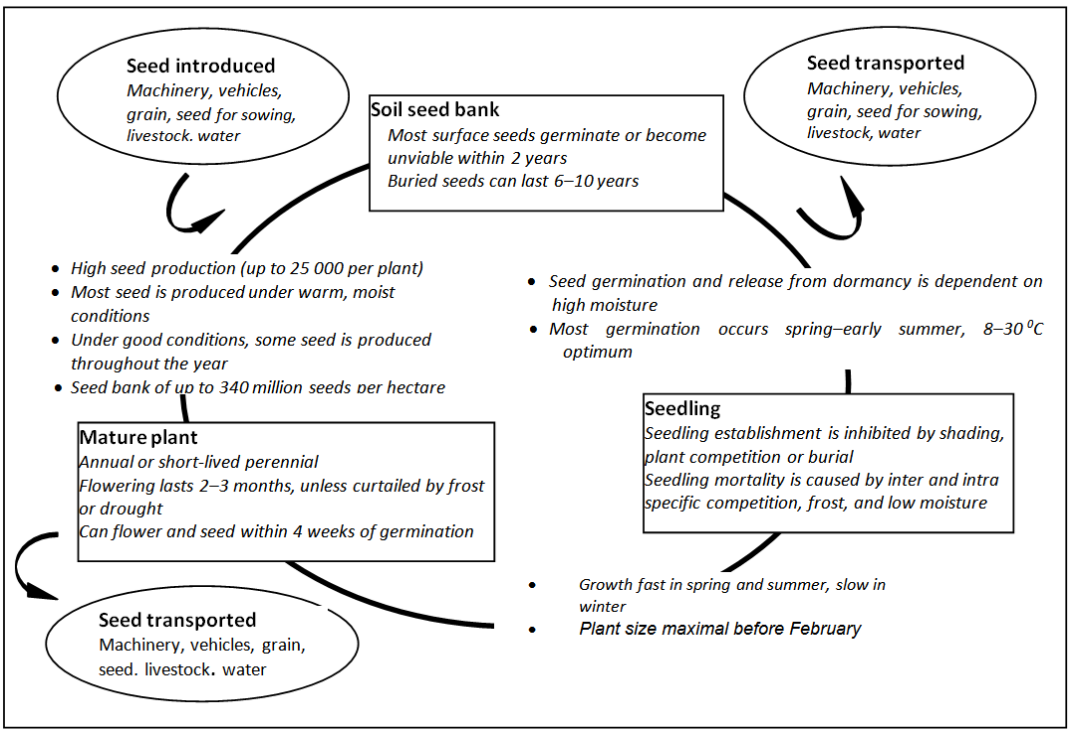


Figure 1 Lifecycle of parthenium weed

In summer, in ideal conditions, plants can flower and produce seeds four weeks after germination. Buried seeds can remain viable much longer than seeds on the soil surface. Timing of chemical control is critical to ensure that parthenium weed is removed when plants are small and have not produced seeds, and when grasses are actively growing and seeding to recolonise the infested area (e.g. in early summer). Studies suggest that after six years, 50% of seeds buried 5 cm below the surface remain viable (Navie et al. 1998b). However, unlike other weed species, there is no critical point where intervention is required, because parthenium weed can produce flowers and seeds at any time of the year under favourable conditions.

2.2 History of spread

Parthenium weed is native to subtropical South and Central America. It has been introduced to many countries in Africa, Asia and the Pacific, and has become a major weed in India, Ethiopia, Pakistan and Australia. It is an emerging weed in Kenya, Uganda, South Africa, Sri Lanka, Bangladesh, Vietnam and China. The first occurrence of parthenium weed in Australia was reported at Toogoolawah, near Esk, in southern Queensland in 1955. Local anecdote suggests it was introduced by American aircraft landing at a local airstrip in the mid-1940s. In 1958, it was present in pasture seed that was distributed near Clermont in central Queensland. Largely unrecognised and untreated, parthenium weed flourished under good growing seasons, with seeds presumably spread by vehicles, machinery, animals, fodder, pasture seed, stock feed and water. Spread was most apparent along roadsides and in areas cleared under the 'Brigalow Scheme'.

Currently, parthenium weed affects 9.4% of Queensland, with the core area of infestation in central Queensland estimated to be 8.5 million hectares. Scattered infestations exist from Cook shire in the north to Longreach in the west, and south to the border river towns of Mungindi and Goondiwindi (Figure 2).

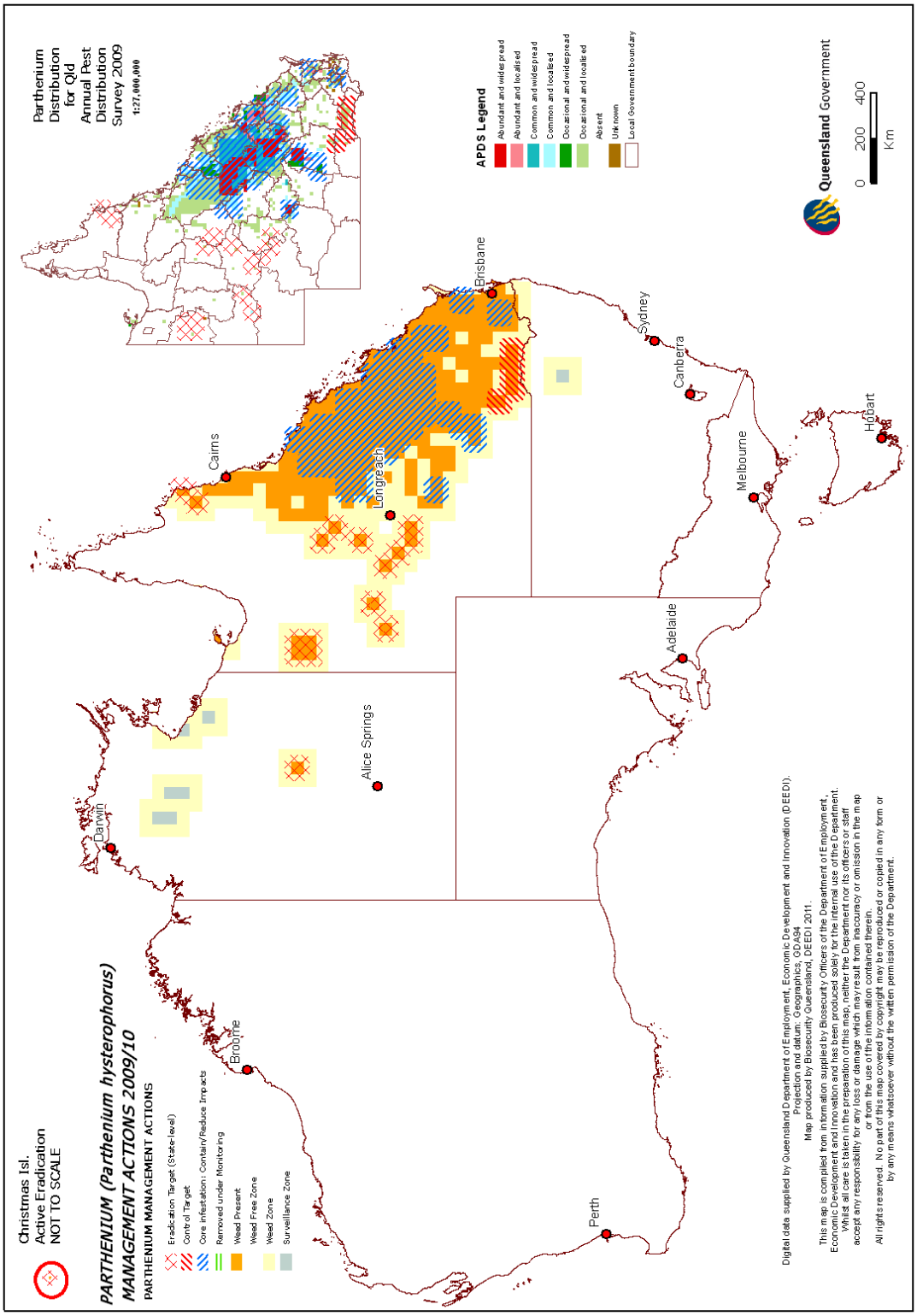


Figure 2 Current distribution of parthenium weed in Australia

Parthenium weed has existed in northern and central New South Wales since 1982, particularly in Moree Plains Shire. A number of roads leading out of Queensland have been infested, with roadside populations as far south as Jerilderie and Deniliquin near the Victorian border. Nevertheless, in New South Wales the extent of the weed has been

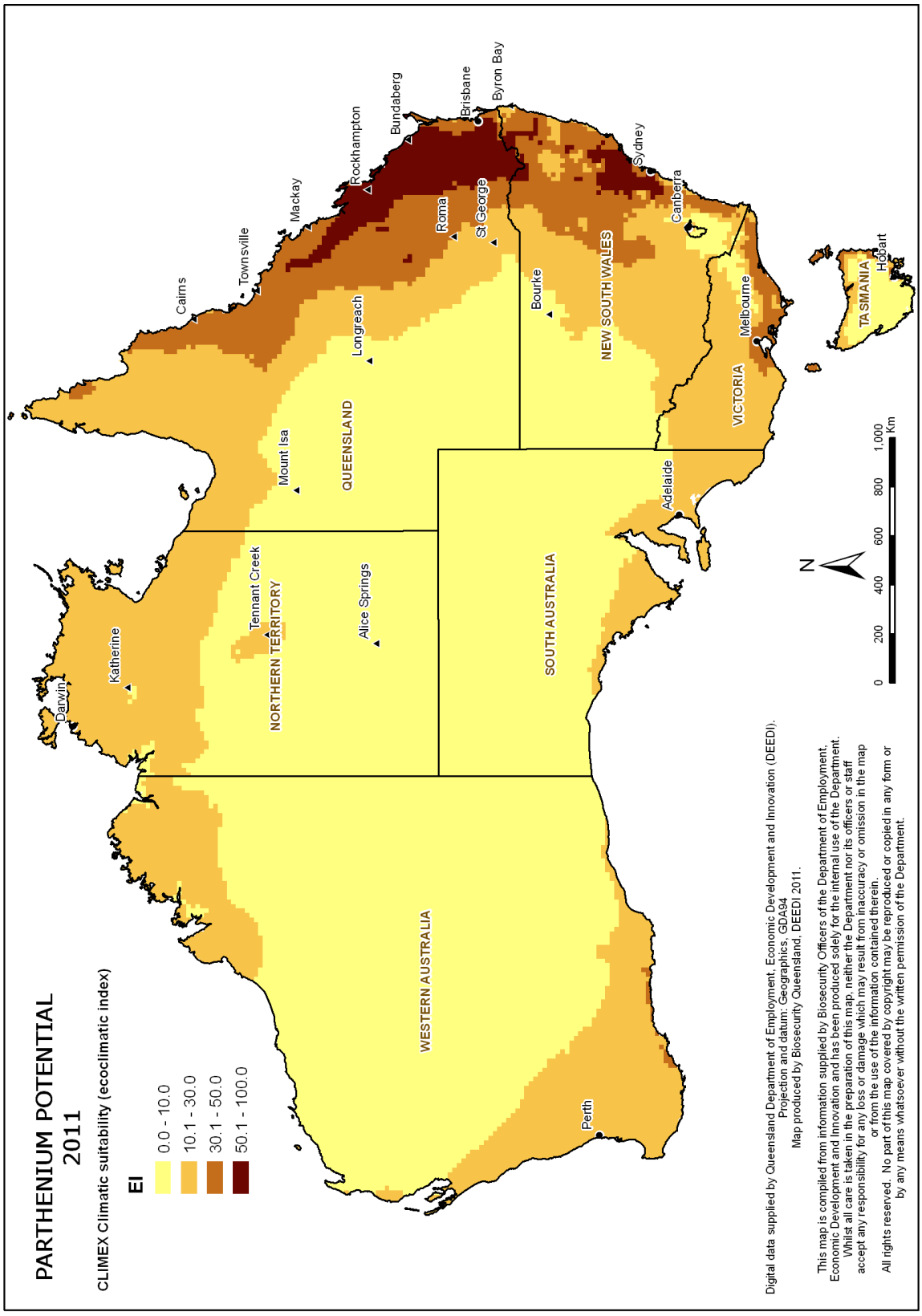
significantly reduced in recent years—all roadside infestations have been suppressed, and all infestations on private land are under active control.

In the Northern Territory, parthenium weed has been eradicated from areas along the Roper River, at Katherine, and in the Gulf of Carpentaria. A small infestation recorded at Tennant Creek in 2009 is subject to an eradication program.

Parthenium weed was recorded at the quarantine wash-down bay near Kununurra, Western Australia, in 2008, and in 2006 was found on Christmas Island where it has been significantly reduced through an ongoing management program.

The potential distribution of parthenium weed in Australia was modelled using CLIMEX.[1] Parthenium weed is best suited to areas where summer rainfall exceeds 500 mm, and could potentially grow in all states of Australia (Figure 3). It has the potential to become a serious weed of medium-rainfall rangelands and summer cropping areas. It is unlikely to become a major weed in winter-rainfall areas because seedling growth is reduced when night temperatures fall below 5 °C, although established plants can withstand at least one light frost (–2 °C). Parthenium weed grows on a wide range of soils—from sand to heavy clay; it favours heavy clay, but growth is reduced on acid soils.

[1] Simulation modelling system developed by CSIRO.



Source: Data is splined from a CLIMEX climate prediction. EI = ecoclimatic index: EI<10 potential for permanent population low, EI>70 potential very high

Figure 3 Potential distribution of parthenium weed

2.3 Summary of impacts

Parthenium weed affects a range of land uses, human health and the environment as summarised below.

2.3.1 Primary production

- Pasture production is reduced because parthenium weed competes with beneficial forage plants; estimated cost is $109 million per year (Adamson 1996).
- Meat can be tainted if livestock (cattle and sheep) eat parthenium weed in sufficient quantities.
- The weed is toxic to cattle and may cause death after 30 days if significant amounts are consumed.
- Cropping costs are higher in both in-crop control and headland management.
- Significant areas of parthenium weed can devalue a property.
- Contamination of livestock (e.g. by seeds carried in mud on hooves), pasture seeds, grain and hay devalues the value of these commodities.
- A host of the Tobacco streak virus in central Queensland.

2.3.2 Health

- There is no treatment for sensitivity to parthenium and no desensitising therapy. Dermatitis, hay fever and asthma can be managed by over-the-counter antihistamine medications but are not always effective. Stronger, prescription-only drugs can have a sedative effect that may result in a potential accident risk and occupational health issues for people operating machinery. Where sensitisation has developed, any contact with contaminated clothing or airborne plant fragments may exacerbate the allergy.
- Allergic responses can be significant, with negative impacts on home, work and social aspects of living. There is a paucity of diagnostic and health care provision for individuals with allergic responses to the weed.
- The cost of treating symptoms can be more than $40 per month for severely affected people.
- It has been suggested that some landholders do not treat parthenium weed for fear of allergic reactions, while others have had to leave parthenium-infested areas due to impacts on their health. Spread of parthenium to non-agricultural areas carries the potential for an increase in sensitisation and associated health-care costs.

2.3.3 Environment

- Parthenium weed is present in 23 reserves and 2 listed wetlands in Queensland and is a significant threat to native grasslands of the central highlands of Queensland (Fensham 1999.)
- Parthenium weed and rubber vine are considered to be the two weeds of greatest threat to biodiversity in the Einasleigh Uplands bioregion (Sattler & Williams 1999).
- Disturbance events, such as floods, can damage native vegetation and allow parthenium weed to flourish in otherwise undisturbed native grass and open woodland communities.

2.4 History of research and management

Parthenium weed management has been ongoing since the 1970s. Actions to prevent, contain and eradicate parthenium include:

- awareness raising activities by state and local governments, industry and community aimed at increasing community knowledge and skills in identification, early detection/reporting and best-management practices;
- establishment of vehicle wash-down facilities (30 facilities at a cost of $3.6 million over the past 10 years,[2] with costs shared by state and local governments, industry and the community)
- strategic roadside spraying program—costs are shared by Main Roads and local government in central Queensland
- distribution of biological control agents
- adoption of best-management practices.

2.5 Control methods

2.5.1 Biological control

The Queensland government has spent nearly $12 million on the biocontrol program (1977–2002). Nine species of insects and two rust fungi have been released in Australia. Research and release of agents is ongoing, and the levels of control achieved are encouraging. Recent releases of summer rust (*Puccinia melampodii*) and the clear-wing Carmenta moth (*Carmenta ithacae*) may further reduce the impact of parthenium weed. An assessment of their impact on weed density is required. The summer rust research project received significant funds from Meat & Livestock Australia ($450 000). Biological control agents are part of an integrated management program for parthenium weed and this element of control should be determined by site-specific circumstances. Consequently, it is recommended that land managers refer to the *Parthenium weed management manual* (Gittens & Chamberlain 2004) for more detail.

2.5.2 Routine management

A range of practices are applied, including measures to avoid spread of seeds, pasture management, herbicide application and biological control. However, the key is to integrate these practices. The validity of each technique and the manner in which they should be integrated depends on site-specific circumstances. Consequently, land managers should refer to the *Parthenium weed management manual* (Gittens & Chamberlain 2004) for more detailed information.

Core infestations

The success of management in core infestations is measured by the reduction in impact. However, if the number of new infestations is increasing, this suggests preventative measures are inadequate.

[2] Under the Natural Heritage Trust (NHT1), 12 facilities were upgraded or established at a cost of $1.6 milion, and under the Queensland Government *Blueprint for the Bush* initiative, 20 facilities were upgraded or established at a cost of $2 million.

Outlier infestations

The management of strategic outlier infestations is vital to protect areas that are currently free from parthenium. Outlier infestations require sufficient resource commitments, including control and follow-up monitoring, in order to fully protect clean areas.

Management in pastures

Managing parthenium weed in pastoral lands relies on grazing management. Matching stock numbers to pasture supply and regular rest during the growing-season maintains pasture condition, minimising parthenium abundance and persistence. It is the single, most powerful strategy to manage parthenium and to prevent new infestations in clean areas.

Grazing management is a less effective tool in the semi-arid rangelands (<500 mm annual rainfall) as grass tends to be naturally sparse and subject to invasion by annual plants (including parthenium) in above-average rainfall seasons or after flood events.

Management in crops

Parthenium weed in crops is normally controlled by fallow management practices (herbicides or cultivation) to reduce soil seed load before crops are planted. Pre-emergent and in-crop herbicides are available for use in wheat and sorghum crops. Cropping industries incur costs of $6 million each year, from additional herbicides and cultivation, to control parthenium.

Damage to sunflower crops caused by sunflower necrosis disorder has had a significant impact on sunflower production in central Queensland since 2004, and in 2005 caused a 20% loss ($4.5 million) across the industry. Tobacco streak virus (TSV) has been identified as a possible cause of the disorder, and can also affect mungbean, chick pea and cotton crops, with the impacts on yield ranging from minor to severe. Several common broadleaf weed species are hosts of TSV, with parthenium weed a key host of the virus in central Queensland.[3]

Herbicides

Herbicide is an important form of control, as part of a best-practice approach, and is widely used along roadsides and to control new, outlier infestations. Timing of application is critical to achieve a successful result; treatment should occur when plants are small and not producing seeds, and when grasses are actively growing to recolonising treated areas.

Management of core infestations relies on land management principles that focus on maintaining pasture health and avoiding overgrazing. The use of herbicide is often reserved for significant germination events, which tend to occur following major early-season rainfall events.

The New South Wales Government spends approximately $200 000 per year to maintain its eradication objective. The largest expense is the border inspections of grain harvesters and the extra time and training related to parthenium weed, which together are estimated to cost $100 000 per year. The Noxious Weeds Grant allocates funds for parthenium weed control and the inspection of roads and properties, which is matched by local governments.

[3] GRDC research update—Tobacco streak virus in grain and pulse crops in Queensland, 090708.

2.6 Socioeconomic factors affecting management decisions

Efficient and effective management of parthenium weed requires the support and cooperation of all stakeholders. Parthenium weed is affecting landholders' livelihoods through reduced sale prices for produce and livestock, retraction of markets, property devaluation and health impacts.

A 2005 survey of Queensland land managers by the Parthenium Weed Management Group indicated that the major limitations for effective control are cost of control (64%), time (51%) and knowledge of control methods (41%). This survey represented a random section of the community involved in managing this weed but barriers to control are likely to be similar across other areas.

2.6.1 Allergic reactions

A significant challenge is to overcome landholders' fear of allergic reactions to parthenium weed. Research has identified individuals and communities at risk from parthenium but further comparative and epidemiological research is important to develop a better understanding of the parthenium sensitisation process. Appropriate methods of conveying the results to those at risk are also needed.

Health education programs for the community, transient workers, employers and industry are required to reduce the risk of sensitisation. Essential in reducing the health risks are measures such as wearing protective clothing, awareness of a personal allergy profile and control methods that minimise contact.

2.7 Quarantine and legislative controls

Parthenium weed is declared in all states and territories (Table 1). The Australian Quarantine and Inspection Service (now Biosecurity Australia) prohibits the introduction of parthenium weed as nursery stock or seed into Australia. In Queensland, it is a mandatory requirement to supply a written notice if supplying goods (i.e. fodder, grain, gravel, machinery mulch, packing material, sand, soil, stock, vehicles or water) containing reproductive material of parthenium weed. Cleaning is also required when goods or vehicles are found to be contaminated with the species.

Table 1 Legislation related to parthenium

Jurisdiction	Legislation	Declaration	Goals and actions
Australian Capital Territory	*Pest Plants and Animals Act 2005*	Parthenium is included on declared pest plant list	Listed as a notifiable and prohibited weed
New South Wales	*Noxious Weeds Act 1993*	Class statewide	The plant must be eradicated from the land and the land must be kept free of the plant
Northern Territory	*Weeds Management Act 2001*	Class A and Class C for all of the Territory	Class A—to be eradicated; Class C—not to be introduced
Queensland	*Land Protection (Pest and Stock Route Management) Act 2002*	Class 2 statewide	Supply or sale prohibited Landholders to control on the land and waters under their control. A local government may serve a notice on a landholder requiring control
South Australia	*Natural Resource Management Act 2004*	Class 1A – Category 1 statewide	N—notifiable throughout the state; plant must be destroyed
Tasmania	*Weed Management Act 1999*	Legal responsibilities are laid out in the Parthenium Statutory Weed Management Plan	The importation, sale and distribution of parthenium weed is prohibited
Victoria	*Catchment and Land Protection Act 1994*	State Prohibited Weed	To be eradicated if possible or excluded from the state
	Agricultural and Related Resources Protection Act 1976	P1, P2 statewide.	P1—introduction of the plant into, or movement of the plant within, an area is prohibited P2—plant to be eradicated in the area

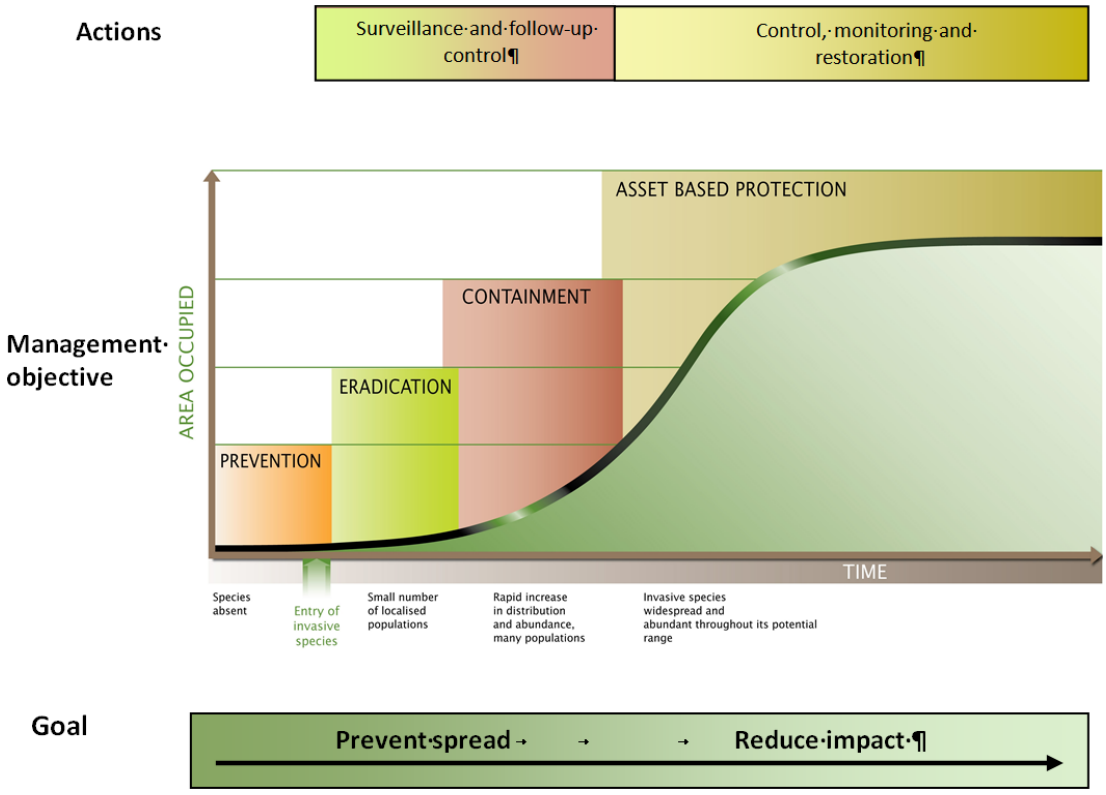
2.8 Principles underpinning the plan

This strategic plan is based on the seven key principles of the Australian Weeds Strategy (NRMMC 2007):

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

The Weeds of National Significance (WoNS) initiative establishes national priorities and facilitates action where there is a significant national or cross-jurisdictional benefit to be gained. These strategic plans do not specifically address resourcing; however, they aim to identify efficiencies and ensure existing resources can be allocated to achieve the most strategic management outcomes.

Effective broadscale management of WoNS and other weeds requires an integrated approach that includes prevention and eradication programs, establishment and implementation of management zones, and the protection of key environmental, social and economic assets in areas where the weeds are already widespread (Figure 4).



Source: Modified from Hobbs & Humphries (1995) and DPI (2010).

Figure 4 Stages of weed invasion with corresponding goals, management objectives and actions at each stage

2.8.1 The national program—progress to date

The first WoNS Parthenium Weed Strategic Plan was published in October 2001, and a National Parthenium Weed Management Group and a coordinator were appointed in 2002 to oversee implementation of the plan.

In 2009, the Natural Resource Management Ministerial Council (Resolution 15.7, 21 May 2009) endorsed a three-phased approach to national management of WoNS species (Appendix 1). The program was reviewed against the strategy objectives in September 2009.[4] Key achievements identified by the review are:

- increased recognition among farmers in northern Australia and New South Wales of parthenium weed as an incursion threat
- adoption of codes of practice and a widespread network of wash-down stations in Queensland for preventing spread
- eradication programs for known populations in New South Wales, Northern Territory, Western Australia, Christmas Island and northern and southern parts of Queensland
- establishment of a pro-active research working group achieving international collaborations
- wide establishment of biological control agents that substantially reduce biomass and fecundity
- development of a best-practice manual and demonstration sites focusing on improved grazing management giving greater productivity
- greater quantification of the human health impacts of parthenium weed
- development of a strong partnership between the state agency, natural resource management groups and local governments focused on preventing establishment in national catchments in south-west Queensland (i.e. Murray Darling Basin and Lake Eyre Basin)
- national mapping of distribution and management actions (Appendix 2).

Key barriers to performance have been:

- logistical, biological, coordination and resourcing challenges to detect and eradicate parthenium weed at a subcatchment scale (particularly in rangeland pastoral areas) because of the weeds' annual life cycle; large, persistent seed bank; short time to seed set; and capacity to germinate throughout the year
- difficulty accessing sufficient external funding for on-ground activities
- compliance problems associated with vendor declarations and mandatory control in key strategic areas in Queensland.

The review recognised a need for ongoing national coordination, with a particular focus on:

- establishing a sustainable, incentive and compliance-based detection and eradication program in southern and western Queensland to prevent establishment in national catchments
- monitoring and evaluation systems for spread prevention, surveillance and eradication projects
- achieving long-term cooperation with Queensland health authorities
- implications of climate change
- maintaining awareness of and improving best practice management in Queensland.

4 Australian Weeds Committee—final review of implementation of the WoNS Parthenium Weed Strategic Plan, 2010

This revised strategic plan represents several months of planning and community consultation. It reflects advice and recommendations from the 2009 WoNS Program Review and is a culmination of input from the National Parthenium Weed Management Group and representatives from local and state governments, industry bodies, natural resource management groups and the community.

2.9 Relevance to other strategies

The Parthenium Weed Strategic Plan 2012–17 has been developed to provide a framework for coordinated management of parthenium weed across the country. Complementary links can be found in a range of existing resource management initiatives at all jurisdictional levels, as shown in Table 2.

Table 2 Strategies and plans for the management of parthenium weed

Scale	Natural resource management	Pest management	Weed species management
National	*Environment Protection and Biodiversity Conservation Act 1999* National Strategy for Conservation of Australia's Biological Diversity 2010 National Strategy for Ecological Sustainable Development 1992	Australian Weeds Strategy 2007 Weeds of National Significance Caring for our Country Business Plan	WoNS Parthenium Weed Strategic Plan
State	State biodiversity and natural resource management strategies Forest policies	New South Wales Invasive Species Plan Northern Territory Weed Management Strategy State agency pest management plans	NSW Parthenium Weed Strategy (2010–15) Northern Territory Parthenium Weed Risk Management Plan
Regional	Regional natural resource management plans	Regional natural resource management investment strategies	Specific weed control plans
Local	Landcare plans Conservation corridor plans Riparian vegetation management plans	Local government pest management plans	Local weed control plans
Property	Property management plans	Property pest management plans National park weed management strategies	Property weed management plans

The goals and objectives in this plan build on those specified in the first strategic plan. The objectives include actions to maintain strategic programs and address management and research needs. Revised actions to achieve these goals are described in Sections 3.1–3.3.

3 Strategic goals

Revised actions to confine parthenium weed to core infestation areas and minimise its impacts are described in Sections 3.1–3.3.

3.1 Goal 1: Prevent new infestations from establishing

Desired outcome: parthenium weed–free areas of Australia are maintained.

The objectives and strategic actions to achieve goal 1 of the strategic plan, and the action level and responsible partners for each action, are shown in Table 3.

Table 3 Objectives and actions to achieve goal 1 of the Parthenium Weed Strategic Plan 2012–17

Objective	Strategic actions	Action level[a]	Responsibility
1.1 Establish protocols to reduce the movement and spread of parthenium weed	Minimise the spread of parthenium:		
	• Establish and promote effective networks of wash-down and inspection facilities/procedures	2	State and territory agencies, industry, WoNS management groups, regional NRM bodies, local governments
	• Develop and advise protocols and standards for cleaning vehicles, machinery and equipment	2	State and territory agencies, industry
	• Increase landholder and land manager awareness of responsibility under relevant legislation	3	State and territory agencies, local governments, industry
	Prevent weed seed spread by high-risk vectors:		
	• Promote adoption of a voluntary vendor declaration for stockfeed and other machinery in other states and territories to complement controls on grain harvesters in NSW	2	NSW Department of Primary Industries, NSW local governments, NRETAS, DAFWA, Vic. DPI, industry
	• Reinforce adoption of vendor weed hygiene declaration responsibilities for Qld	1	Queensland Department of Agriculture, Fisheries and Forestry, local governments, industry, regional NRM bodies
	Develop and implement 'codes of practice' to reduce parthenium weed seed contamination and spread	2	Industry groups, state and territory agencies, utilities
1.2 Detect and record infestations through a surveying and mapping program	Establish procedures for early detection of parthenium weed:		
	• Promote the value for landholders and other members of the community to report sightings of parthenium weed	1	Local government, state and territory agencies, landholders
	• Develop protocols for inspection and treatment of roadsides to include – high-risk riparian areas – research—assess the effectiveness	2	Local government, state and territory agencies

Objective	Strategic actions	Action level[a]	Responsibility
	and timing of chemical applications (best-practice roadside management)		
	Establish procedures for receiving and responding to reports of infestations, and build a rapid response capability	1 (2 in Qld)	Local government, state and territory agencies
	Maintain detailed records and reports on all new outbreaks in a parthenium weed database	2	Local government, state and territory agencies
1.2 Detect and record infestations through a surveying and mapping program *(continued)*	Establish a monitoring system for previously treated infestations: • Regularly reinspect treated outbreaks • Ensure follow-up control treatments are completed in a timely manner to ensure no germination is evident	2	Local government, state and territory agencies Landholders, local government, state and territory agencies
1.3 Eradicate new infestations	Develop priority areas for each region with parthenium weed, with management objectives based on management zones Implement management zones based on core infestations, containment, prevention and eradication	1	State and territory agencies, local governments
	Eradicate parthenium weed from small or isolated outbreaks:	1	All stakeholders
	• Maintain and support parthenium weed eradication programs for the whole of WA, SA, Tas., Vic., NSW, ACT and NT		State and territory agencies, local governments,, industry and landholders
	• Establish a sustainable, incentives and compliance-based detection and eradication program in southern and western Qld to prevent establishment of new infestations to include riparian areas	3	Qld local governments and landholders
	Establish monitoring and evaluation systems for spread prevention, surveillance and eradication projects	2	State and territory agencies, local governments, industry
1.4 Use compliance as a management tool	Train authorised officers on procedures and guidelines for inspecting properties and machinery, and enforcing pest management legislation	2	State and territory regulatory agencies, local governments
	Ensure that the power to inspect vehicles, plant and equipment, and require them to be cleaned is exercised in accordance with relevant legislation	2	State and territory regulatory agencies, local governments
	Encourage stakeholders to comply with legislative requirements and take action when breaches occur	2	State and territory agencies, local government, industry

ACT = Australian Capital Territory; DAFWA = Department of Agriculture and Food Western Australia; DEEDI = Department of Employment, Economic Development and Innovation; DPI = Department of Primary Industries; NSW = New South Wales; NRETAS = Natural Resources, Environment, the Arts and Sport (Northern Territory); NRM = natural resource management; NT = Northern Territory; Qld = Queensland; SA = South Australia; Tas. = Tasmania; Vic. = Victoria; WA = Western Australia; WoNS = Weeds of National Significance

a The Australian Weeds Committee (AWC) applied three action levels that reflect jurisdictional commitment to implementing actions:
Level 1 = Highly beneficial as a national action that is critical to success of the WoNS revised strategic plan and all relevant AWC jurisdictions have committed resources to implementing this action.
OR
Highly beneficial to a particular jurisdiction and the responsible party/ies have committed resources to implement this action.
Level 2 = Highly beneficial at national and/or jurisdictional level, but implementation will be subject to resource availability and investment priorities.
Level 3 = Desirable and still beneficial to improving uptake and efficiency of on-ground action, but not critical to success.

3.2 Goal 2: Strategically manage existing infestations

Desired outcome: The adverse impacts of, and emanating from, established parthenium weed infestations are minimised.

The objectives and strategic actions to achieve goal 2 of the strategic plan, and the action level and responsible partners for each action, are shown in Table 4.

Table 4 Objectives and actions to achieve goal 2 of the Parthenium Weed Strategic Plan 2012–17

Objectives	Strategic actions	Action level[a]	Responsibility
2.1 Maintain strategic containment programs	Maintain parthenium weed strategic containment programs to support management of parthenium weed through a zone approach	1	Regional bodies, state and territory agencies, local government
	Develop a zonal management plan that identifies the management objectives for different zones		
2.2 Implement best-practice parthenium weed management	Develop and promote tailored awareness and extension activities to support effective implementation programs. Key themes include: identification spread prevention protocols and best-practice management techniques	1	State and territory agencies, NRM regional bodies, local government, research institutions
	Train key stakeholder operatives in best-practice management of parthenium (identification, prevention and management protocols)	2	State and territory agencies, local governments, NRM regional bodies
2.3 Develop and implement targeted communication program	Develop and implement a targeted national communication program including: • television and radio advertising • a range of promotional and media initiatives • support pest management program into education curriculum	1	State and territory agencies, local governments, NRM regional bodies, industry peak bodies
	Disseminate and direct information and awareness campaigns to target groups in all at-risk regions		

Objectives	Strategic actions	Action level[a]	Responsibility
2.4 Investigate the impacts of parthenium weed under a changing climate	Assess the impacts of parthenium weed under a changing climate through research including:	2	
	• biology and ecology—reproduction and persistence, biotypes, impact on biodiversity and disease transmission		Research institutions
	• management—role of competitive plants, discovery of new biological control agents, aerial chemical application, development of economically balanced integrated management packages		University of Queensland, state and territory agencies
	• spread—prevent spread by vehicles, animals, wind and water, and map the potential spread		NRM regional bodies, local governments, industry
	• physical impacts on human and animal health and the consequent economic impacts on human, animal, environment and production systems		Queensland Health
	• network development—extension approaches to national and international scientific and farming communities		

NRM = natural resource management

a The Australian Weeds Committee (AWC) applied three action levels that reflect jurisdictional commitment to implementing actions:
Level 1 = Highly beneficial as a national action that is critical to success of the WoNS revised strategic plan and all relevant AWC jurisdictions have committed resources to implementing this action.
OR
Highly beneficial to a particular jurisdiction and the responsible party/ies have committed resources to implement this action.
Level 2 = Highly beneficial at national and/or jurisdictional level, but implementation will be subject to resource availability and investment priorities.
Level 3 = Desirable and still beneficial to improving uptake and efficiency of on-ground action, but not critical to success.

3.3 Goal 3: Increase the capability and willingness to manage parthenium weed

Desired outcome: national commitment to parthenium weed is maintained.

The objectives and strategic actions to achieve goal 3 of the strategic plan, and the action level and responsible partners for each action, are shown in Table 5.

Table 5 Objectives and actions to achieve goal 3 of the Parthenium Weed Strategic Plan 2012–17

Objectives	Strategic actions	Action level[a]	Responsibility
3.1 Increase stakeholders' commitment to parthenium weed management	Raise the profile of parthenium weed as a significant issue for all stakeholders in all states and territories and engender the support required to manage it effectively	1	State and territory agencies, local governments, regional NRM bodies, industry
	Encourage all Queensland stakeholders to increase their commitment to the coordinated control of parthenium weed in Queensland—to maintain effort in containing parthenium weed to protect southern, western and northern Queensland	1	State and territory agencies
	Establish coordination mechanisms/forums across key stakeholders to maximise parthenium weed management	1	State and territory agencies
3.2 Manage the implementation of the strategy	Facilitate implementation of the strategic plan	1	All stakeholders, state, territory and Australian government agencies
	Collate strategic plan milestones and report on progress annually to the Australian Weeds Committee, stakeholders and funding groups	1	State and territory agencies
3.3 Monitor the implementation of the strategy	Establish an ongoing evaluation methodology for the strategy: • Monitor and evaluate progress towards this strategic plan against a phase 3 monitoring, evaluation, reporting and improvement (MERI) plan	1	All stakeholders
3.4 Develop cooperative management frameworks to deliver strategic objectives	Ensure a link of parthenium weed national strategy with state and regional NRM planning schemes at the state, regional and local levels	1	State and territory agencies, NRM regional bodies and local governments

NRM = natural resource management

a The Australian Weeds Committee (AWC) applied three action levels that reflect jurisdictional commitment to implementing actions:
Level 1 = Highly beneficial as a national action that is critical to success of the WoNS revised strategic plan and all relevant AWC jurisdictions have committed resources to implementing this action.
OR
Highly beneficial to a particular jurisdiction and the responsible party/ies have committed resources to implement this action.
Level 2 = Highly beneficial at national and/or jurisdictional level, but implementation will be subject to resource availability and investment priorities.
Level 3 = Desirable and still beneficial to improving uptake and efficiency of on-ground action, but not critical to success.

4 Monitoring, evaluation, reporting and improvement framework

The Australian Weeds Strategy (NRMMC 2007) gives the Australian Weeds Committee (AWC) responsibility for monitoring and evaluating the management of national priority weeds, including WoNS. The AWC is therefore responsible for monitoring and reporting progress under this strategic plan.

This strategic plan is subject to a five-year review; however, mechanisms must also be put in place to allow the goals and actions to be evaluated throughout this period. This enables ongoing assessment of progress towards intermediate and long-term outcomes, and, ultimately, helps to determine the effectiveness of individual actions. It also helps to identify program improvements, and provides evidence to stakeholders and funding bodies that they are getting value from their investment.

Individual jurisdictions and/or organisations responsible for weed management and conservation will need to develop their own monitoring strategies. They should, where possible, coordinate actions to implement this plan, and monitor and evaluate progress towards its goals in conjunction with existing state, regional or local plans. While individual actions should be monitored at the jurisdictional level, data or evidence collected as a part of state, regional and local activities or plans should be provided to the AWC and collated so that it can be assessed each year within the national context. This will help to build a comprehensive overview of the plan's delivery. Table 6 lists key evaluation questions that should be assessed by the AWC each year at the national level to ensure progress against strategy goals, and which should be used to provide the basis for an annual report to the AWC.

This monitoring, evaluation, reporting and improvement (MERI) framework lists the basic reporting information that should be collected for the life of the strategic plan—including during phase 3 delivery (see Appendix 1). This will ensure that sufficient data are collected to identify successes and failures, and provide the opportunity for improvement where outcomes are not being achieved. Annual MERI plans may be developed to follow activities in more detail.

Although performance indicators or other ways of measuring progress are not provided in this strategic plan, a scoring system could be appropriate.

The National Parthenium Weed Management Group developed a program logic model outlining key activities required to achieving national parthenium management (Appendix 3). This process ensured that there are logical links between strategic actions and intermediate to long-term program objectives. The strategy documents the stakeholders' commitments and provides a clear framework for the coordinated management of parthenium weed as a WoNS, and provides advice to the Australian Weeds Committee on progress.

Table 6 Suggested monitoring and evaluation questions to measure progress under the phase 3 WoNS Parthenium Strategic Plan 2012–17

WoNS:	Jurisdiction:		Date:
Goal	**Key evaluation questions**	**Data or evidence required**	**Consider**
1 Prevent new infestations from establishing	To what extent have new infestations been prevented from establishing?	1.1 National distribution data: Has the national distribution map been reviewed and/or updated? Has the Priority Management Action spreadsheet been updated?	• Are these documents publicly available? • Have stakeholders been advised of any changes? • Where is this data or information stored? • Does this information capture national priorities?
		1.2 New infestations: Number of new infestations recorded Percentage of known infestations actively controlled	• Are any new infestations occurring in areas identified as a high priority in the national strategy? • How were infestations detected (passive or active surveillance, community reporting etc.)? • Have high-risk pathways been adequately identified? • Have threats been minimised?
		1.3 Eradication and containment programs: Percentage of eradication and/or containment programs being maintained	• What percentage of programs identified in the national strategy are being actively managed? • Is there a plan in place for ongoing management? • How is progress being monitored and reported to stakeholders? (Examples using case studies can be included)
		1.4 Legislation: Legislation or policy changes for this species Legislative change has been identified by stakeholders	• What legislative changes have been made? • Are minimum requirements being maintained (e.g. ban on sale, trade, movement? • Is control required throughout or in part of the jurisdiction? • Is compliance actively enforced?
			Score:

Table 6 ***continued***

WoNS:	**Jurisdiction:**		**Date:**
Goal	**Key evaluation questions**	**Data or evidence required**	**Consider**
2 Strategically manage existing infestations	To what extent is integrated weed management effectively managing core infestations?	2.1 Integrated weed management: Effectiveness of integrated weed management programs	• Are existing tools providing adequate control of WoNS? • Have new advances or technologies been developed and are they incorporated into best-practice management information? • Are there barriers to adoption of best-practice management? • Are research programs addressing any observed gaps (e.g. herbicide trials, biocontrol, restoration requirements post-control)?
	To what extent are assets being protected through strategic management?	2.2 Asset protection: Number of priority assets identified as 'at risk' from WoNS Percentage of priority assets being protected (e.g. assessed against relevant threat abatement plans) Percentage of state and regional invasive species plans that identify priority assets at risk from WoNS	• Methods by which assets are being protected (e.g. targeted annual spray programs, high-risk pathway surveillance, strategic plans) • Are long-term monitoring programs in place to detect change? • To what extent is management leading to an improvement in asset condition? (Response should include status report on progress towards asset-protection programs)
			Score:
3 Increase capability and commitment to manage WoNS	To what extent has the capability and commitment to manage WoNS increased?	3.1 Community engagement and awareness: What is the status of best-practice information? Are partnerships being maintained to ensure collaboration on WoNS? Number and type of media activities	• Is best-practice information up to date and readily available? • Is this information and/or advice being targeted to priority regions? • Is training being delivered to meet the needs of weed managers (including the community)? • Are networks and groups being supported (e.g. through dissemination of research outcomes,

Table 6 ***continued***

WoNS:	Jurisdiction:		Date:
Goal	**Key evaluation questions**	**Data or evidence required**	**Consider**
			funding opportunities, control options etc.)? • Has awareness and engagement in WoNS management been raised effectively?
		3.2 Resourcing: From what sources are programs being funded?	• Number of projects funded by Australian Government, jurisdictions, industry, etc.
		3.3 Policy and planning: Are the objectives of the strategy being integrated into Australian Government/state/regional plans, policies and programs? Has cross-border collaboration occurred?	• How are priorities reflected in planning and policy approaches (e.g. weed risk assessments, invasive species plans, asset-protection plans, district plans, weed spread prevention activities, management programs, incentive programs, state working groups)? • How are national priorities being maintained (e.g. containment lines, eradication targets, training and awareness raising, research projects)?
			Score:
Continuous improvement	Are there any unexpected outcomes that have been identified through implementation of strategy?	Barriers: • Have any other management issues or impediments been identified?	

WoNS = Weeds of National Significance
Scoring:
1: Insufficient evidence to score
2: No progress has been made against this goal
3: Limited progress is being made against this goal
4: Reasonable progress is being made against this goal
5: Excellent progress is being made against this goal

5 Stakeholder responsibilities

Although landowners have primary responsibility for the control of parthenium weed on their land, relevant agencies share responsibility for the actions listed in Sections 3 and 4. The effective implementation of this strategy requires the involvement of a range of stakeholders. Stakeholders' responsibilities may vary between jurisdictions: some actions may be optional while others are prescribed by legislation. The successful achievement of strategic actions relies on the development and maintenance of partnerships between community, industry and government, and recognition of the roles of each stakeholder. In particular, while the National Parthenium Weed Management Group provided oversight for the original strategy, future coordination arrangements will evolve to maintain and build on past achievements. The Australian Weeds Committee, at a national level, and various agencies at the state and territory level will continue to provide a leadership role. Suggested responsibilities for each group are listed below.

Private landholders

- Improve skills to detect parthenium weed and recognise its negative impacts.
- Implement best-practice management where necessary.
- Report infestations to support management of parthenium weed.
- Support weed hygiene practices to prevent weed seed spread.

Natural resource management bodies

- Provide leadership to coordinate extension and education strategies to highlight impacts and best-practice management solutions for parthenium weed.
- Incorporate strategic parthenium weed control at regional level natural resource management planning and investment processes.
- Coordinate and source funding for strategic management programs in partnership with key stakeholders.
- Help coordinate stakeholders by implementing strategic management programs to support parthenium weed management zones, particularly buffer zones.
- Support stakeholders that adopt best-practice parthenium weed management.
- Support mapping and reporting of parthenium infestations.
- Implement monitoring and reporting protocols in line with the MERI plan and provide relevant information to the relevant state government agency for national reporting purposes.

Local governments

- Enforce legislation (where necessary) and establish local management policies to contribute to the management of parthenium weed.
- Coordinate and source funding for strategic management programs in partnership with key stakeholders.

- Incorporate strategic parthenium weed control in local government planning and investment processes, including promoting its inclusion in property pest management plans.
- Coordinate extension and education strategies to highlight impacts and best-practice management solutions for parthenium weed.
- Support implementation of work in priority management areas.
- Support weed hygiene practices to prevent weed seed spread.
- Map and report parthenium weed infestations.
- Identify and implement incentive programs.
- Monitor and evaluate management outcomes and strategy implementation in line with the MERI plan, and provide relevant information to the relevant state government agency for national reporting purposes.

Utility companies, agribusiness, industry, research institutions

- Implement best-practice management
- Improve skills to detect parthenium weed and recognise its negative impacts.
- Support weed hygiene practices to prevent weed seed spread.
- Promote and adopt best-practice management of parthenium weed.
- Contribute to extension and education on the impacts of parthenium weed.
- Contribute to research and development of alternative parthenium weed management practices to support industry members.
- Conduct and support applied research to address priority national strategic requirements.
- Collaborate with stakeholders to seek ongoing funding and support for research requirements.

Lead agencies, other government departments in states and territories

- Contribute to the management and delivery of the WoNS initiative.
- Incorporate strategic parthenium weed management priorities with state regional and local-level planning and investment processes
- Coordinate and source funding for strategic management programs in partnership with key stakeholders.
- Identify and adopt strategic management areas; that is, parthenium weed management zones.
- Include the strategic control of parthenium weed on state lands in agency pest management plans and ensure this translates to on-ground outcomes.
- Introduce and enforce legislation and policy covering strategic management of parthenium weed.
- Provide leadership to coordinate extension and education strategies to highlight impacts and best-practice management solutions for parthenium weed.

- Implement monitoring and reporting protocols in line with the MERI plan and provide relevant information to the Australian Weeds Committee for reporting purposes.
- Contribute to priority research areas in support of strategic objectives.
- Develop and implement long-term extension and education programs for target areas and audiences highlighting the impacts of parthenium weed.
- Collect and provide a centralised storage and access point for parthenium weed mapping information.

Australian Government departments and corporations

- Provide adequate resourcing to ensure the effective coordination and monitoring of the parthenium weed WoNS strategy.
- Ensure strategic parthenium control is undertaken on all federally managed lands.
- Oversee and manage federal funds including Caring for our Country and other future funding programs.
- Provide research support through CSIRO and the Commonwealth Weeds Research Group.

Australian Weeds Committee

- Review and oversee implementation of the Parthenium Weed WoNS Program
- Promote links between WoNS strategies and the Australian Weeds Strategy.
- Report the benefits of the WoNS initiative to upper level government at state, territory and Commonwealth levels.

Appendix 1 The Weeds of National Significance initiative and its phases[1]

In 2007, an independent review of the WoNS initiative concluded that the nationally strategic approach of WoNS was highly successful in leveraging consistent multijurisdictional activity on high-priority weed species. This initial review was followed by a detailed review of the inaugural WoNS species by the Australian Weeds Committee (AWC) in 2009–10. The AWC reviewed the implementation of the 20 WoNS national strategies and, in light of achievements for these 20 species, considered the capacity for national coordination of additional WoNS species.

Following the reviews, the Natural Resource Management Ministerial Council (Resolution 15.7, 21 May 2009) endorsed a three-phased approach to national management of WoNS species (Figure 5). This 'phased approach' aims to provide the most cost-effective use of limited 'national coordination' resources.

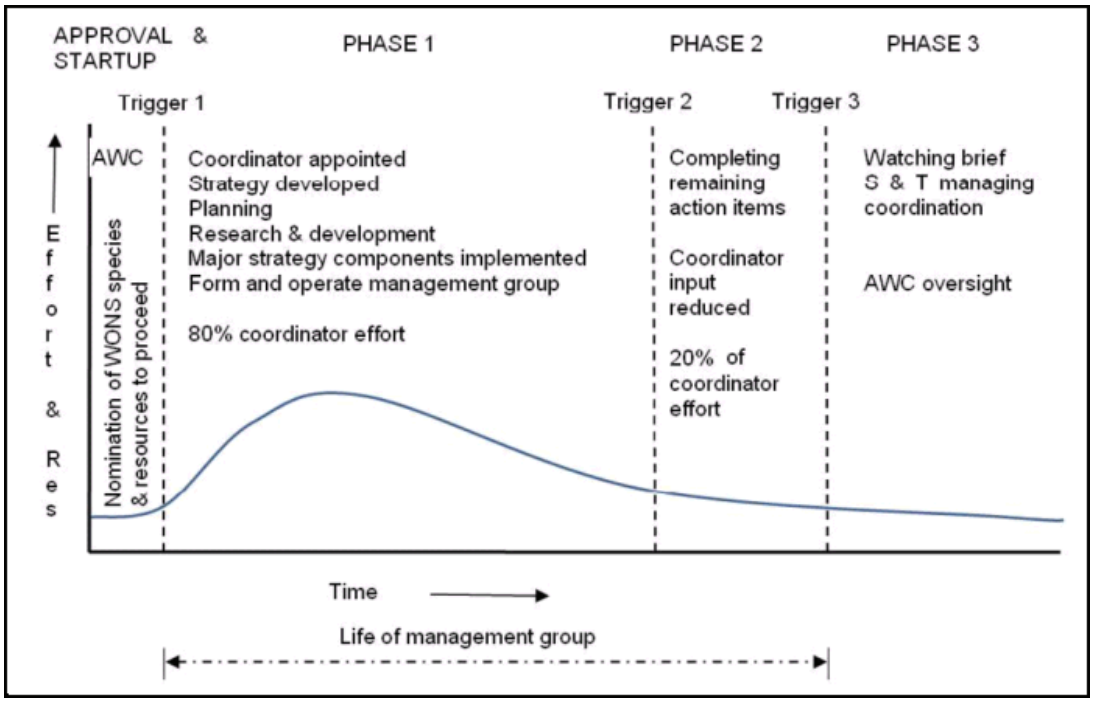


Figure 5 Australian Weed Committee diagrammatic representation of coordinator effort and resource use when implementing a Weeds of National Significance strategy

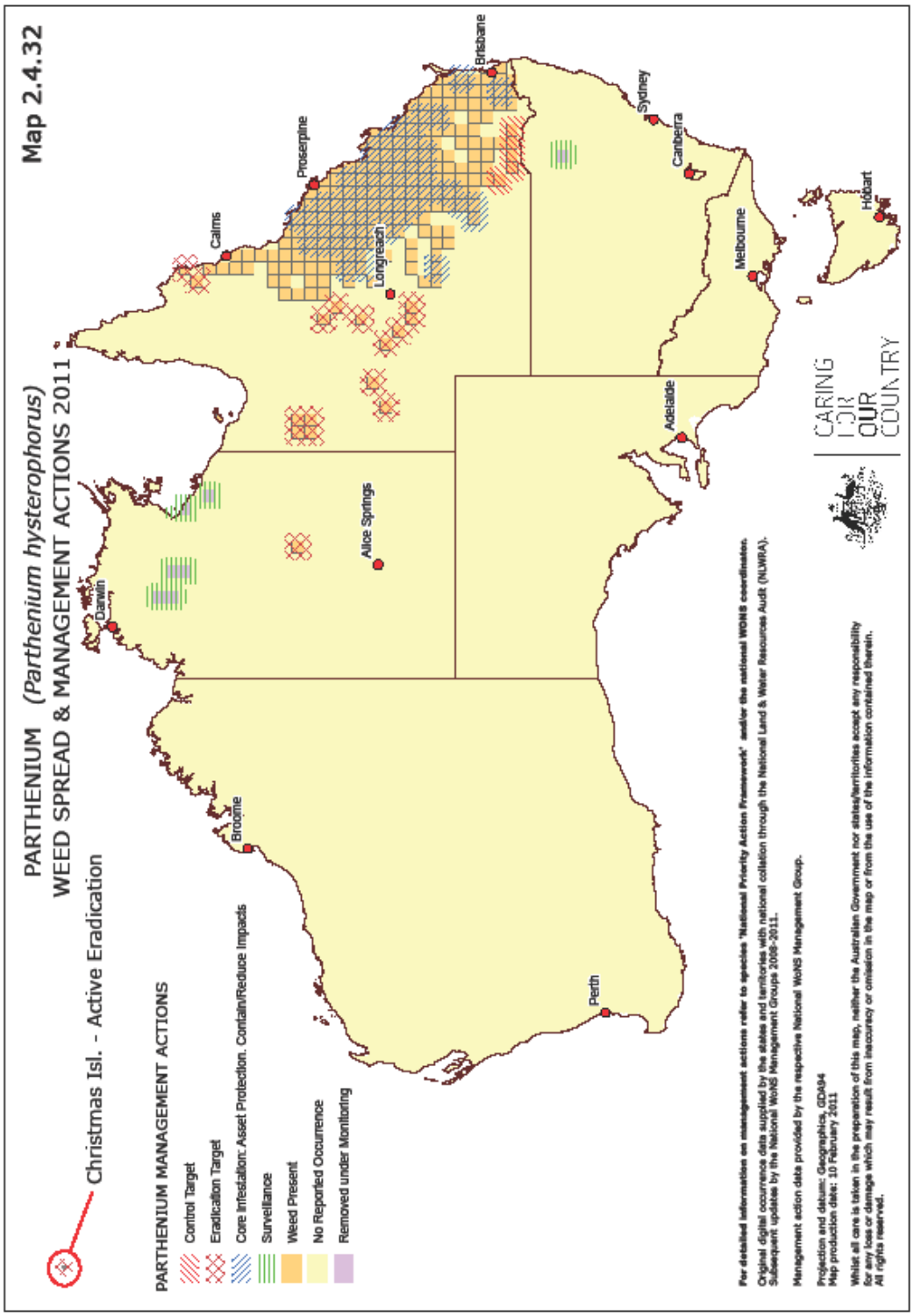
The phased approach recognises the need for reduced national coordination ('phasing down') of WoNS species that are under effective national management, and allows for further weed species to be nominated for consideration as additional WoNS. The AWC is implementing these reforms, and national coordination of the inaugural 20 WoNS species has already transitioned to phase 2 or 3, depending on the species. No species have yet been

[1] Adapted from Thorp 2012, *Additional list of Weeds of National Significance*, <www.org.au/WoNS>.

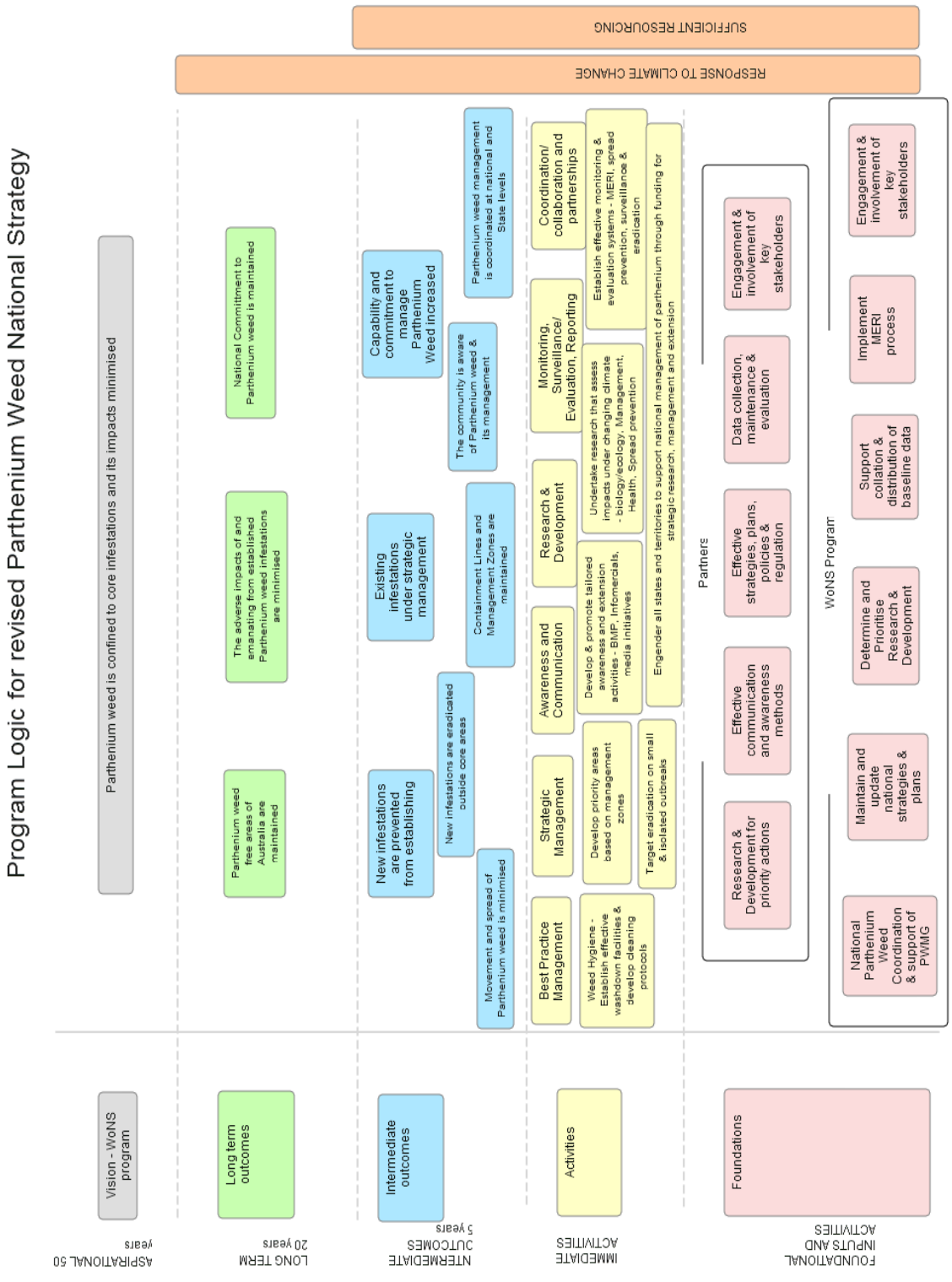
removed from the WoNS list. The AWC is developing a protocol to guide future decisions about when this should occur on a case-by-case basis.

In 2010, jurisdictions nominated additional candidate WoNS species. These species were independently assessed, and the AWC endorsed 12 additional 'species' to be listed as WoNS. The AWC Chairman, Dr Jim Thompson, announced these additional plant species as WoNS on 20 April 2012. Additional information on the selection of these species and the phased approach is available on www.weeds.org.au/WONS.

Appendix 2 National parthenium weed distribution and management zone map



Appendix 3 Program logic model for the parthenium weed strategic plan



References and further reading

Adamson, D 1996, 'Determining the economic impact of parthenium on the Australian beef industry: a comparison of static and dynamic approaches', Masters thesis, University of Queensland, Brisbane.

Anon. 2003, W*eed management guide—parthenium weed*, CRC for Australian Weed Management, Adelaide.

Anon. 2005, 'Assessment of parthenium weed awareness, knowledge and control methods through the use of extension products', parthenium weed questionnaire, Department of Natural Resources, Mines and Energy, Queensland.

Anon. 2009, *Parthenium weed*, Pest Fact PP2, Queensland Department of Employment, Economic Development and Innovation, Brisbane.

Anon. 2010, AWC Review of implementation of the WoNS Parthenium Weed Strategic Plan, Australian Weeds Committee. Canberra

Chippendale, J & Panetta, FD 1994, 'The cost of parthenium weed to the Queensland cattle industry', *Plant Protection Quarterly*, vol. 9, pp. 73–76.

Dhileepan, K 2009, 'Managing parthenium weed across diverse landscapes: prospects and limitations', in Inderjit (ed), *Management of invasive weeds*, Springer Science, pp. 227–260.

Dhileepan, K & Strathie, L 2009, '*Parthenium hysterophorus* L. (Asteraceae)', in R Muniappan, GVP Reddy & A Raman (eds), *Biological control of tropical weeds using arthropods*, Cambridge University Press, Cambridge, pp. 272–316.

DPI (Victorian Department of Primary Industries) 2010, *Invasive plants and animals policy framework*, State Government of Victoria, Melbourne.

Fensham, RJ 1999, 'Native grasslands of the central highlands, Queensland, Australia', *Rangelands Journal*, vol. 21, no. 1, pp. 82–103.

Gittens, A & Chamberlain, J 2004, *Parthenium weed management manual—challenges, opportunities and strategies, for parthenium weed (*Parthenium hysterophorus*)*, Queensland Department of Natural Resources, Mines and Energy, Brisbane, pp. 12–21.

Hobbs, RJ & Humphries, SE 1995, 'An integrated approach to the ecology and management of plant invasions', *Conservation Biology*, vol. 9, pp. 761–770.

Navie, SC, McFadyen, RE, Panetta, FD & Adkins SW 1998a, '*Parthenium hysterophorus* L.', in FD Panetta, RH Groves & RCH Shepherd (eds), *The biology of Australian weeds*, vol. 2, RG and FJ Richardson, Melbourne, pp. 157–176

Navie, SC, Panetta, FD, McFadyen, RE & Adkins, SW 1998b, 'Behaviour of buried and surface-sown seeds of *Parthenium hysterophorus*', *Weed Research*, vol. 38, pp. 338–341.

NRMMC (National Resource Management Ministerial Council) 2007, *Australian Weeds Strategy—a national strategy for weed management in Australia*, Australian Government Department of the Environment and Water Resources, Canberra.