WEEDS OF NATIONAL SIGNIFICANCE

Silverleaf nightshade

(*Solanum elaeagnifolium*)

Strategic Plan 2012 to 2017

ISBN [to be completed by secretariat]

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, their management committees and copies of the strategy.

This strategy was developed under the leadership of John Heap, PIRSA, SA with full cooperation of all the States, Territories and Commonwealth of Australia.

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

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CONTENTS

EXECUTIVE SUMMARY

Silverleaf nightshade (*Solanum elaeagnifolium*) is recognised as one of the world's worst agricultural weeds, and has recently been included as one of 12 new Australian Weeds of National Significance (WoNS). It currently infests over 350,000 ha of productive farmland, is still spreading, and has the potential to infest almost all of the farmlands in the cereal growing regions of SA, NSW, Vic and WA. Once established, there are no practical methods available to destroy large core infestations. It is a competitive, tenacious, drought-tolerant perennial weed that has a very extensive and resilient root system. Once established it has a chronic and debilitating effect on productivity, often reducing crop and pasture yields by 20 to 40%. Herbicides that are suitable for use on crop production land give only short to medium-term control of shoots and seed set. New shoots can re-grow quickly, nourished by the reserves of the deep root system. Cultivation, mowing and burning are ineffective, and competitive crops and pastures give only limited control. There are currently no biological control agents established in Australia, although progress has been made in South Africa.

This strategic plan defines a focused and coordinated national five year approach needed to prevent new infestations from occurring, find and destroy outlier infestations, and to reduce the impact of established core infestations on the productivity of the cereal zone that underpins Australia's agricultural production. It is founded on the seven key principles of the Australian Weeds Strategy, and adopts the three common goals of all WoNS projects: 1) New infestations are prevented from establishing; 2) Established infestations are under strategic management, and 3) There is greater capability and commitment to manage silverleaf nightshade. The plan relies on shared responsibility and enthusiasm from a wide range of stakeholders. This can only be achieved through commitment, teamwork, consultation, involvement, awareness, capacity building and the formation of enduring partnerships. The plan aligns with the Australian Weeds Strategy, and will be implemented by a national stakeholder group who will report to the Australian Weeds Committee (AWC) using an agreed monitoring, evaluation, reporting and improvement (MERI) framework.

A coordinated, national management program involving a wide range of stakeholders is proposed, using key objectives and strategic actions under the three goals:

- Goal 1: *New infestations are prevented from establishing*. Goal one will focus on preventing new infestations from occurring or establishing. Key propagule sources, vectors and invasion pathways will be indentified and managed. Stakeholder awareness and vigilance will be crucial to ensure that new and priority outlier infestations are eradicated and monitored.
- Goal 2: *Established infestations are under strategic management*. Goal two will improve management of existing, established core infestations to protect the major agricultural assets at risk. The emphasis will be on filling knowledge gaps, delivering best practice management guides, and encouraging strategic management of infestations to improve crop and pasture yields and reduce propagule spread. Biological control and allelopathy from *Eucalyptus* spp. will also be reviewed to identify opportunities.
- Goal 3: *Greater capability and commitment to manage silverleaf nightshade*. Goal three will concentrate on building enduring awareness, capacity and motivation. A key objective is to establish a silverleaf nightshade national management group. Mapping and research activities will improve the effectiveness of management, and inform prioritisation. Best management practice information will be delivered through published resources and stakeholder meetings. Landholders will be motivated to control silverleaf nightshade by provision of economic modelling and case studies, and stakeholders will be encouraged to integrate the goals of this plan into regional and state/territory planning.

Vision /Aspirational Goal

The vision of this strategy is that new infestations of silverleaf nightshade in Australia will be minimised through increased surveillance and eradication, and that the impacts of existing core established infestations will be reduced through improved management, capacity, motivation and coordination.

1 THE CHALLENGE

Figure 1. Established core infestation of silverleaf nightshade – there are currently no economic options available to reduce infestations like this.

Silverleaf nightshade is a summer-growing perennial weed from the Americas that grows to 60cm high and invades disturbed habitats. It was introduced to Australia accidentally and now severely reduces crop and pasture productivity over a wide area. It is one of the world's worst weeds of arable land and occurs in many countries. The major asset at risk is the productivity of the entire mainland cereal cropping belt of southern Australia from southern Qld, through NSW, Vic and SA, to WA. This area underpins our agricultural export base and domestic food security. Once established it is extremely difficult to kill, due to a perennial root system that can extend to a depth of 4m. It has been in Australia since at least 1901 and extensive established infestations now cover over 350,000 ha in SA, NSW and Vic across a wide range of soil-types and annual rainfall. There are also less extensive infestations in WA and Qld. It continues to spread within the important Australian cereal cropping production zone, primarily by seed transported by livestock and farm produce, and also by root and stem fragments. Examination of a map of potential distribution of silverleaf nightshade in Australia (Fig. 3) shows that some areas of southern Qld and large parts of arable WA are at risk. Large-scale distribution maps do not, however, show the potential for clean, highly productive paddocks on the same farm as a recorded infestation, or on nearby farms, to be colonised. There is still a serious risk for very large areas of clean, productive, arable agricultural land to be infested in SA, NSW, Vic and WA.

New infestations can be locally eradicated, if discovered and treated quickly. Once infestations become established (Fig. 1) and spread to cover larger areas (c. >10ha) eradication is very difficult. These infestations continue to spread by clonal root growth (c. 2m per year), and by root/stem fragments transported to other parts of the paddock, and further afield to neighbouring paddocks and farms.

Spread by seed, particularly in berries eaten by sheep, is the most important invasion pathway in Australia. It is likely that seeds are spread around Australia every year, often over large distances by livestock transported in trucks. Seedling emergence during summer and autumn is common, but most seedlings are killed by dry and hot conditions following a single rainfall event. Recruitment of seedlings to initiate new infestations, however, appears to be sporadic and is probably associated with particular critical rainfall event patterns during summer. At the regional level silverleaf nightshade may appear to spread slowly for a

number of years, then apparently explode in response to successful recruitment of seedlings following a favourable series of rainfall events within one summer.

Silverleaf nightshade is primarily controlled using herbicides. In Australia attempts to identify suitable biological control agents have made little practical progress so far, however there has been some success in South Africa. Cultivation, mowing, grazing and burning have little effect on the perennial root system. Competition from deep-rooted perennials can reduce shoot vigour, and there is evidence that some *Eucalyptus* spp. suppress growth through allelopathy. Small infestations can be eradicated using expensive and persistent herbicides but these treatments are not suitable for large areas (> 10 ha). Shoots of large established infestations can be killed by a range of herbicides, but regrowth occurs from the perennial roots. Temporary control of shoots is useful to restrict seed production and to increase the yield of following crops and pastures.

The challenge for silverleaf nightshade management is to increase levels of capacity, awareness, and willingness to manage this weed before it spreads to its full potential geographic range and severely reduces Australia's important agricultural production base. Establishment of new infestations must be minimised through surveillance and eradication. Established large infestations should be managed using best practice management to reduce propagule production, and increase crop and pasture yields. Management of all infestations around Australia will need motivated people - backed by sound technical advice and support.

2 INTRODUCTION

This document was prepared by the national silverleaf nightshade coordinator following consultation with a range of key stakeholders. Public comment was invited and received via a range of pathways, including a feedback form available on www.weeds.org.au/WoNS/silverleafnightshade. Following public comment and additional stakeholder feedback this national silverleaf nightshade (*Solanum elaeagnifolium*) strategic plan has been endorsed by AWC. The strategic plan is based on WoNS principles and templates, published literature, stakeholder consultation, and the author's experience through extensive research and extension activities with silverleaf nightshade.

National weed management is guided by the Australian Weeds Strategy (AWS) and the WoNS initiative is a key part of this strategy designed to deal with Australia's most significant weeds. The aim of this strategic plan is to provide an agreed, accepted and coordinated plan to reduce the spread and impact of silverleaf nightshade in Australia, informed and driven by stakeholders and a silverleaf nightshade national management group (SLNNMC).

Return on investment will flow from reducing current and future impacts of silverleaf nightshade on the agricultural regions of southern mainland Australia. This will be achieved through an integrated and coordinated approach that discovers, delimits and destroys new infestations; manages established infestations to reduce propagule spread and increase productivity; and builds capacity, willingness and resilience to manage this weed into the future. The clear emphasis will be on protecting many millions of hectares of valuable and productive clean agricultural land from continued invasion.

The implementation of this plan includes collaboration and communication across the wider WoNS initiative. Synergies, consistent public messages and value-adding activities will be achieved through whole-of- WoNS cooperation. The plan identifies national strategic action priorities and encourages key stakeholders to engage in coordinated cross-jurisdictional activities to manage silverleaf nightshade throughout Australia.

2.1 Principles underpinning the plan

The national silverleaf nightshade strategic plan is underpinned by seven key principles from the Australian Weeds Strategy, and the three key common goals of the WoNS initiative. The need for collective and coordinated action against WoNS is clearly articulated in the seven key principles of the AWS, which are distilled into the three major goals of the strategic plan.

The Australian Weeds Strategy key principles are:

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 under pins 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 three major goals common to all WoNS projects are derived from the AWS strategy and are:

1) New infestations are prevented from establishing.

2) Established infestations are under strategic management.

3) Greater capability and commitment to manage silverleaf nightshade.

In addition to the AWS, WoNS strategic plans are also aligned to the 2012 Intergovernmental Agreement on Biosecurity (IGAB; COAG 2012), which outlines national invasive species management objectives. IGAB aims to enhance Australia's biosecurity system by fostering a collaborative approach to minimise the impact of pests across the biosecurity continuum, including "a national management framework to ensure that nationally significant pests and diseases established in Australia are contained, suppressed or otherwise managed." WoNS initiatives contribute to this aim by facilitating coordinated, strategic management of nationally significant weeds.

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

In most instances, complete control of widespread weeds is unachievable. However, well researched, strategic and coordinated management approaches can reduce current and potential impacts and provide a good return on investment. Effective widespread weed management requires an approach that spans the biosecurity continuum (Figure 2) that underlies the goals and objectives of this plan, moving from the preferred option of prevention before an area is invaded, through to strategic asset protection where core infestations are widespread.

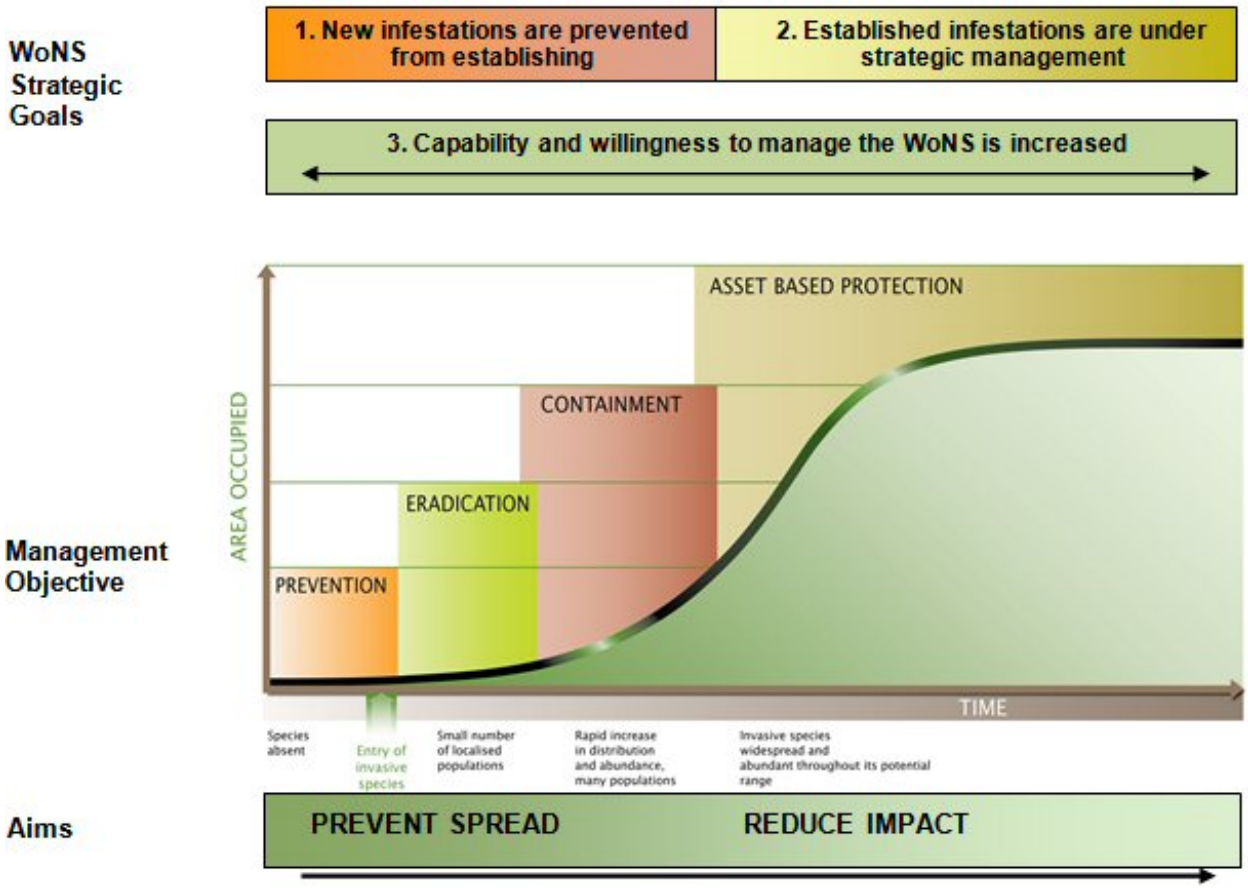


Figure 2 - Biosecurity continuum - Stages of weed invasion with corresponding goals, management objectives and actions at each stage (Modified from Hobbs and Humphries 1995; and DPI 2010).

2.2 The current situation

Distribution. Silverleaf nightshade now occurs throughout most regions of the cereal cropping zone of the southern Australian mainland (Fig. 3**).** This rich and extensive “grain basket” of Australia underpins our valuable export and domestic agricultural economy. The majority of infestations occur in SA, Vic and NSW. In WA there are approximately 50 outbreaks that are of critical interest to this plan because they occur in areas that are very suitable for silverleaf nightshade growth. A similar situation exists in southern Qld.

The cereal cropping zone hosts a range of valuable major enterprises including cereals (e.g. wheat, barley, triticale, oats), pulses (e.g. peas, beans, lentils, lupins, vetch), oilseeds (e.g. canola), hay production, grazing (e.g. sheep, cattle), and myriad minor enterprises. In addition, horticultural enterprises such as wine, vegetable and fruit production are at risk. The current and potential risk posed to irrigated crops (e.g. cotton, rice) will be investigated as a part of this plan.

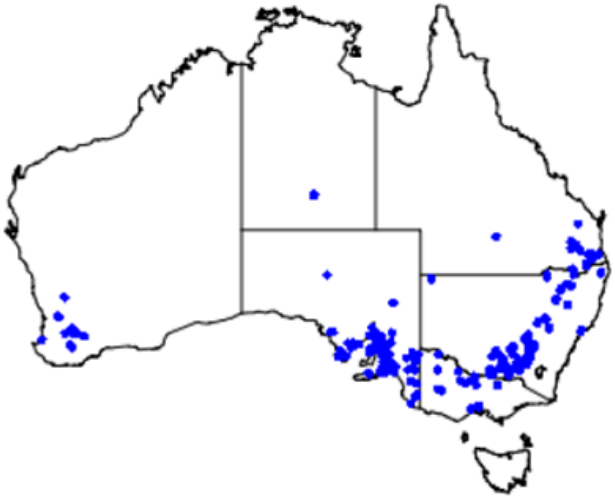


Figure 3. Australian silverleaf nightshade 2011 distribution.

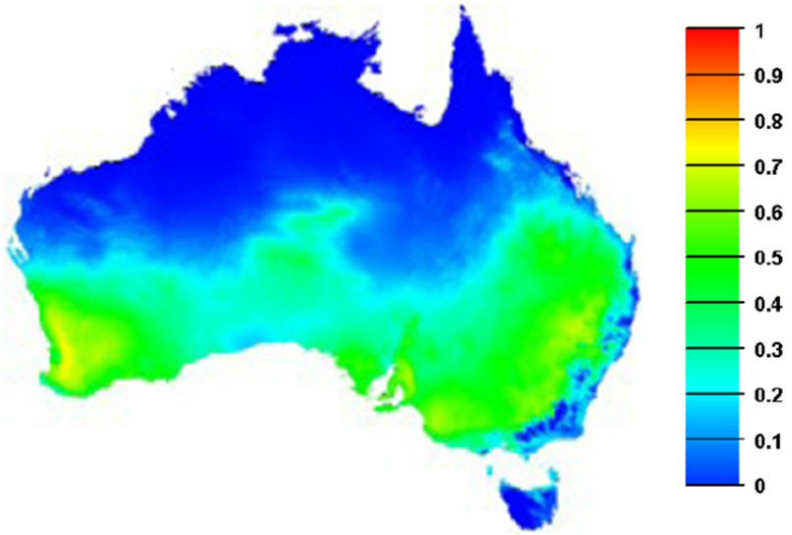


Figure 3. Australian silverleaf nightshade potential distribution
Distribution 0 = very poorly suited location; 1 = highly suitable location.
Maps from Wilson *et al*. (2011).

Assets at risk. There are three major areas of concern that are at risk from further invasion of silverleaf nightshade:

1) *The large and productive cereal cropping belt of south-west WA.* A relatively small number of infestations have spread slowly, probably restricted by the rarity of specific sequences of summer rainfall events needed to allow recruitment of seedlings. These infestations are a source of long-distance seed spread, the extent of which may become alarmingly apparent if favourable summer rainfall conditions do occur one summer. It may be prudent to consider the feasibility of intensive management of these relatively few infestations to minimise the most important seed source in WA, and allow natural soil seed bank reserves to dissipate in unknown locations to which seed has probably already spread.

2) *Large areas of productive arable land within the "current distribution" range of silverleaf nightshade*. Silverleaf nightshade occurs commonly throughout the cereal cropping zone of SA, Vic and NSW, but within this zone there are very large areas that are not yet invaded. Good management allows clean paddocks to resist invasion from neighbouring paddocks on the same farm or nearby farms. There are also large districts within the cereal cropping zone of SA, Vic and NSW that have little or no silverleaf nightshade. These clean areas are a priority asset for protection because of their close proximity to propagule sources and exposure to invasion pathways.

3) *Horticultural and irrigated crops*. Overseas experience from regions with similar soils and climate to southern Australia suggests that horticultural and irrigated crops are at risk from silverleaf nightshade. There is already evidence that silverleaf nightshade has invaded some horticultural land (e.g. Northern Adelaide plains, Riverland of SA), but the situation with irrigated crops (e.g. cotton, rice) needs to be further investigated. It appears likely that the potential risk is high, but so far invasion has been slow due to restricted introduction of contaminated livestock to horticultural land.

Legislation: Silverleaf nightshade is a declared weed in at least some regions of SA, Vic, NSW, and Tas. A summary of the legislated status of silverleaf nightshade was obtained from http://www.weeds.org.au/noxious.htm in June, 2012, and is presented in the Technical Background section (Appendix 7.1). Declared weed lists are currently undergoing change in some states and territories.

WoNS selection. Silverleaf nightshade was selected as a WoNS due to its invasiveness, competitiveness, fecundity, accessibility, invasive pathways, and a high level of expected cooperation from landholders. It was thought to be highly likely to spread over long distances, and recognised as being very difficult to control once established. It was also recognised that it was present in many jurisdictions, but presently only infests a small proportion of its potential distribution.

Current management. A major research and extension effort in the mid 1970s and another smaller effort in the 1980s prevented some spread, eradicated some new infestations, and contributed to improved understanding of biology and management of large established infestations. Since then a low-level of ad-hoc research has been maintained and control efforts have been undertaken mainly by NRM/CMAs. There has been little coordination between states beyond extension activities associated with some research projects. Anecdotal evidence suggests that there is often a gap between legal obligations and actual on-ground control undertaken. This gap is pragmatic and exists due to the difficulty and expense of controlling established infestations. Management action zones and legislation should be sympathetic to these considerations in order to preserve land-holder goodwill and willingness to accept reasonable and achievable management goals. Land manager attitudes and silverleaf nightshade management vary widely, ranging from poor and disinterested through to enthusiastic and excellent. The differences appear to reflect individual motivation (personality), attitude to legislated obligations, support from local authorities, and involvement with local action groups.

Stakeholders. There have been a range of stakeholders throughout Australia identified with an interest in the national silverleaf nightshade strategic plan. A summary of the interests and potential roles for the plan is given below:

Farmers and graziers (e.g. cereal cropping belt farmers). These are the major stakeholders, because they manage most of the assets at risk. Often crop and grazing enterprises are combined on the same property. Attitudes and management of silverleaf nightshade vary widely from region to region, and farmer to farmer (see above). There is generally a willingness to manage silverleaf nightshade, but there must be a demonstrable economic imperative for them to do so. The threat of production loss should be sufficient to encourage surveillance and eradication, and crop/pasture yield losses should motivate annual control efforts for established infestations. Awareness must be raised amongst farmers from relatively “clean” regions who have not yet encountered the effects of established silverleaf nightshade infestations.

Horticulturalists (e.g. vegetable and fruit growers). The potential risks, and key invasion pathways, need further investigation and publicity. Some are already affected, and dense infestations can occur because these crops are often irrigated during summer, when silverleaf nightshade grows.

Local government/shire/council authorities. Graders and droving stock can spread propagules. These infestations often assume disproportionate importance because land managers may point to these infestations when expressing resistance to mandated management of silverleaf nightshade on their own properties.

Amenity managers (e.g. airfields, irrigation channels, military bases, reserves and housing estates). Many infested amenity areas have been developed on land near settlements with a long agricultural history, and pre-existing silverleaf nightshade infestations. Often the managers have limited weed management knowledge and capacity. The threat posed by these infestations is generally low because the potential for propagule movement to other areas is low, unless livestock are agisted.

Consultant agronomists (e.g. Landmark agronomists, State Govt. DPI District Agronomists). As farming becomes increasingly complex it is common for farmers to employ private agronomic consultants who give a range of agronomic advice, including weed control advice. In some regions government consultants (district agronomists) fulfil a similar role. These are a key stakeholder group because each can influence up to 50

growers (greater with government agronomists). Knowledge and capacity varies widely, depending on length of experience.

Research providers (e.g. University, Govt. research organisations, local action groups). These are key stakeholders because they can fill knowledge gaps to improve the effectiveness and efficiency of management strategies. In the current financial environment projects usually need to be fully funded from external sources. If adequate funding is available, most organisations are willing to conduct specified research. Local action groups have a valuable role to research and demonstrate issues at a regional level so that local ownership and motivation is increased. It is important that a research and development portfolio be coordinated across Australia to avoid duplication and omission of critical research.

Research funders (e.g. CfoC, GRDC, MLA). Commonwealth funders (e.g. CfoC) may fund research and control activities involving silverleaf nightshade as part of broader initiatives. Industry-based RIRFs (e.g. GRDC, MLA) usually fund projects relating to a particular industry, however GRDC (grains) and MLA (meat and livestock) may have an interest in collaboration on silverleaf nightshade research. Securing sufficient research funding is crucial to filling knowledge gaps because most research providers require projects to be fully funded from external sources.

State government agencies (e.g. State Departments for Agricultural and Environmental management). These stakeholders host project coordinator roles and often influence the activities of NRM/CMA and local government weed control authorities. They also have influence on legislation relating to weeds. There may be opportunities to access funding from these stakeholders to pursue state-based research, development, and control activities against silverleaf nightshade.

National weed management entities (e.g. AWC, AG). Historically national NRM programs have provided a governance framework and some funding of WoNS projects.

NRM/CMA and local government weed control officers (e.g. weed and vertebrate pest control officers). These stakeholders are the “frontline troops” for government-mediated weed control activities. They possess detailed local knowledge about infestations and the nature and capability of many constituent land managers. Most importantly they have valuable knowledge about the usefulness and practicality of proposed strategic actions in their regions.

Local community weed/SLN action groups (e.g. group of farmers running local weeds trials). These groups do not have the capability of dedicated research organisations (e.g. state Primary Industries departments, Universities), but their activities are very valuable. Often these projects arise from or lead to the formation of small groups of farmers with a common interest in silverleaf nightshade. These groups promote and build local capability, ownership and willingness, and provide a convenient focal point for extension activities. This will often be the catalyst needed for other less motivated farmers in the district to ask questions and increase awareness.

Herbaria/mapping staff. All of the WoNS projects will require the engagement and collaboration of herbaria facilities and specialist mapping expertise. There are compelling reasons for a coordinated, whole-of-WoNS approach to mapping activities.

Chemical companies. Current control methods for silverleaf nightshade plants rely almost exclusively on herbicides (see 6.5 for details). Chemical companies are important stakeholders for refining use of their products, registering new uses, and supporting off-label permit applications.

2.3 Strategic plan development

This plan is based on WoNS principles and templates, published literature, stakeholder consultation, field visits, and the coordinator’s experience through extensive research and extension activities with silverleaf nightshade. It is planned that a national stakeholder workshop will be convened in 2012-13, and a proposed silverleaf nightshade national management group (SLNNMC) will help to refine the implementation of this plan.

2.4 Relevance to other strategies

Table 1. Relevance of the national silverleaf nightshade strategic plan to other strategies and plans within Australia.

Scale	Strategies and Plans
National	Australian Weeds Strategy (2007).
State	State/territory biodiversity and invasive species plans.
Regional	Natural resource management/ catchment management area regional plans, biodiversity and invasive species strategies and plans.
Local	Weed control plans, property management plans, local government weed management strategies/plans.

3 STRATEGIC GOALS AND OBJECTIVES

The national silverleaf nightshade strategic plan is underpinned by seven key principles from the Australian Weeds Strategy, and the three key common goals of the WoNS initiative (see 2.1 above). The AWS key principles highlight that effective weed control priorities are an essential part of sustainable management of natural resources, should be informed by risk management processes and underpinned by good science, and are a shared responsibility that requires all parties to have a clear understanding of their coordinated roles. The principles also recognise that prevention and early intervention are the most cost-effective techniques, and that building stakeholder capacity and motivation is fundamental. The projects within the WoNS initiative share three major goals that distil the essence of the AWS principles. These are listed in the table below, along with a range of objectives, arranged under the three common WoNS goals that will need to be met for effective and enduring management of silverleaf nightshade. Further details of goals precede each of the three goal tables that follow. Objectives within the goal tables are prioritised 1 to 3, as follows:

Priority 1 = Critical to the success of the strategic plan.

Priority 2 = Highly beneficial and will contribute significantly to the success of the strategic plan.

Priority 3 = Desirable, still beneficial, but not critical to the success of the strategic plan.

Collaborative decision making by responsible partners

Aspirational objectives in this plan are supported by strategic actions that identify how these objectives can be achieved. Further work will be needed to refine the actions and/or develop methods to implement the actions. This work will be done in a consultative manner with all responsible partners. Thus, it is important that the correct partners be identified and included in the decision making process and, where appropriate, that they identify an appropriate level of participation for implementing actions. Decisions regarding implementation of national priority actions will be informed by the proposed SLNNMC, in collaboration with responsible partners and other relevant stakeholders.

Table 2. Strategic goals and objectives

Strategic Goal	Objectives
• New infestations are prevented from establishing.	1.1 **Propagule sources and vectors are identified, evaluated and prioritised at a regional level.**
	1.2 **Propagule movement is minimised by effective management of invasion pathways.**
	1.3 **Surveillance efforts are informed and supported to ensure timely detection of new infestations.**
	1.4 **Priority outlier infestations are delimited, destroyed or managed, and monitored.**

	1.5 **Large, established infestations are managed to minimise propagule spread along identified pathways.**
• Established infestations are under strategic management.	2.1 **Knowledge gaps for best management practice for large established infestations are identified and addressed.**
	2.2 **Priority assets at risk (including both infested and clean land) benefit from management of large established infestations.**
	2.3 **Biological control opportunities are reviewed and promoted.**
• Greater capability and commitment to manage silverleaf nightshade.	3.1 **Reliable distribution maps suitable to inform strategic management decisions are produced.**
	3.2 **Capability to manage SLN is increased by current best management practice tools, information, education and support for stakeholders.**
	3.3 **Willingness and motivation to manage SLN is increased by improved awareness and knowledge of its economic impacts, supported by case studies.**
	3.4 **Capability and willingness to manage SLN are increased by a SLN network and SLNNMC.**
	3.5 **Stakeholder capabilities and ownership increased by encouraging research, development and local community projects.**
	3.6 **Plans, policy and legislation at local to national jurisdictional levels incorporate or support the SLN strategic plan.**
	3.7 **The SLN national strategic plan is relevant, effective, and its implementation is supported by stakeholders.**
	3.8 **Resilient long-term management of SLN is promoted through establishment of enduring structures, capabilities and resources.**

3.1 GOAL 1: New infestations are prevented from establishing

Prevention and early intervention are the most cost-effective methods to control weeds. New infestations must be found quickly and where possible, eradicated. To do this it is critical to understand silverleaf nightshade biology, key invasion pathways, and key vectors of spread. The majority of surveillance will be done by farmers, on their own land. It is very important that they have a high level of awareness and easy access to informed identification and technical support, and are assisted with eradication activities. Awareness programs will be driven by targeted extension activities, underpinned by good maps and an understanding and management of key invasion pathways. Management of core infestations is also critical for prevention, because it

minimises the sources of propagules. The major vector and invasion pathway in Australia appears to be sheep that have eaten mature berries during late summer and autumn, and then are subsequently transported to other paddocks, farms, regions and states. This pathway will receive particular attention, and represents the best opportunity to significantly reduce spread.

Objectives	Strategic Actions	Priority	Responsible Partners
1.1 Propagule sources and vectors are indentified, evaluated and prioritised at a regional level.	1.1.1 . Encourage research and collate information on seed biology, seedling recruitment, and viability of root and stem fragments under field conditions.	1	SLNNMC, research
	1.1.2. List and prioritise key vectors and seasonal invasion pathways at a regional level. Address: ▪ Distribution of propagule sources	1	SLNNMC, research, NRM/CMA, LGA, local action groups, landholders

	▪ Importance of various vectors ▪ Seasonality of invasive pathways		
	1.1.3. Investigate the use of the National Livestock Identification System (NLIS) to identify high-risk invasion pathways involving sheep and other livestock, and initiate a dialog with livestock traders/carriers.	1	SLNNMC, research, NLIS
1.2 Propagule movement is minimised by effective management of invasion pathways.	1.2.1. Produce reliable distribution maps to identify propagule sources (see 3.1).	1	SLNNMC, research, NRM/CMA, LGA, S&T.
	1.2.2. Engage and educate seed/fragment producers, likely seed/fragment recipients, and livestock traders/carriers on invasion pathways (see 3.2).	2	SLNNMC, NRM/CMA, LGA, local action groups
	1.2.3. Include a hygiene protocol in the best practice management guide that aims to minimise spread of seed and vegetative propagules.	1	SLNNMC, research
1.3 Surveillance efforts are informed and supported to ensure timely detection of new infestations.	1.3.1. Publicise key invasion pathways and the importance of prevention and early detection of spread using a range of methods, including: ▪ Printed and web-based information ▪ Print and electronic media ▪ Stakeholder meetings and conversations	1	SLNNMC, research, NRM/CMA, LGA, local action groups
	1.3.2. Ensure definitive identification information is readily available at the regional and land manager level.	1	SLNNMC, research
	1.3.3. Encourage and facilitate inclusion of new infestation details into a central mapping database, including attempts to estimate ages of infestations based on size/extent.	2	SLNNMC, research, NRM/CMA, LGA, S&T, local action groups, landholders
	1.3.4. Investigate the use of detailed analysis of summer rainfall events to identify high risk periods for seedling recruitment and transplanted stem/shoot fragment establishment.	2	SLNNMC, research

Objectives (cont.)	Strategic Actions	Priority	Responsible Partners
1.4 Priority outlier infestations are delimited, destroyed or managed, and monitored.	1.4.1. Assist regional NRM/CMA and LGA staff to be knowledgeable and responsive to reports of new SLN infestations.	1	SLNNMC, researchers, S&T
	1.4.2. Encourage research and collate information on best practice for destroying small infestations.	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups, landholders
	1.4.3. Investigate establishment of regional/state management zones to identify priority outlier infestations.	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups, landholders
	1.4.4. Define attributes and response plans for highly significant outlier infestations that may require special attention.	1	SLNNMC, NRM/CMA, LGA, S&T
	1.4.5. Develop and disseminate protocols for effective long-term monitoring of new incursions under management.	2	SLNNMC, NRM/CMA, LGA, S&T, local action groups
1.5 Large, established infestations are managed to minimise propagule production and spread along identified pathways.	1.5.1. Educate managers of large, established SLN infestations on the importance of reducing propagule production and spread so that clean areas on their own and other's properties are protected.	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups
	1.5.2. Ensure that adequate information is available on minimising seed set, reducing spread from fragments, and livestock as vectors (See 2.2).	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups

3.2 GOAL 2: Established large infestations under strategic management

Large, established core infestations are common throughout SA, Vic and NSW. There is no practical method for eradication of these infestations, and so strategic management is currently the only option. The table for Goal 2 describes the plan for managing core infestations. Many farmers consider core infestations to be intractable, and are often unwilling to manage them. It is clear that legislated obligation alone is insufficient motivation in most cases, and that economic imperatives must be documented and publicised to raise awareness and willingness. There is good evidence that treatment of core infestations with herbicides during summer has economic benefits for following winter crops and pastures through increased yield. The cost of control of flowering and seed-set must be justified in terms of minimising seed spread to clean areas via livestock. If there are clean areas on the same farm, then the benefits do, at least partially, accrue to the manager. If, however, the whole farm is already infested, then the benefits accrue to the buyer of the livestock. Raised awareness amongst potential livestock purchasers might help to build a premium into the market for clean stock, thus restoring the economic imperative in the later case. Effective biological control is the most satisfactory solution to management of core infestations, and this option will be reviewed and investigated further.

Objectives	Strategic Actions	Priority	Responsible Partners
2.1 Knowledge gaps for best management practice for large established infestations are identified and addressed.	2.1.1. Assess Australian and international literature and consult with stakeholders to identify knowledge gaps (see 3.5).	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups, landholders
	2.1.2. Provide detailed information on how treatment of large established SLN infestations can be effectively combined with routine summer weed control for other species.	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups, landholders
	2.1.3. Liaise with funding bodies (CfoC, GRDC, MLA etc.) and research providers to seek support for a range of research and development projects (including local action groups) to address knowledge gaps.	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups, landholders
2.2 Priority assets at risk (including both infested and clean land) benefit from management of large established infestations.	2.2.1. Protect crop and pasture assets by providing land managers and other stakeholders with cost-effective management options (best practice management guide) and advice, including economic imperatives.	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups, landholders
	2.2.2. Minimise propagule sources to protect clean land assets by encouraging managers to reduce seed set and fragment movement.	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups
	2.2.3. Produce reliable distribution maps to identify propagule sources and priority assets at risk (see 3.1).	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups
	2.4.4. Investigate sociological and attitudinal aspects of management of large established infestations.	2	SLNNMC, researchers
2.3 Biological control opportunities are reviewed and promoted.	2.3.1. Review existing information and progress towards biological control and identify any opportunities for progress.	1	SLNNMC, researchers, S&T
	2.3.2. Liaise with agencies conducting biological control research to encourage interest in any opportunities, and assist with any new funding applications.	1	SLNNMC, researchers, S&T
	2.3.3. Inform stakeholders about the biological control process, potential and limitations in general, and specifically for SLN.	2	SLNNMC, researchers, NRM/CMA, LGA, S&T

3.3 GOAL 3: Capability and willingness to manage silverleaf nightshade increased

Capacity and motivation are key attributes that will help to build strong and enduring partnerships, and they are covered by the table for Goal 3. Reliable and current distribution maps are important for identifying priority outlier infestations, and for managing propagule sources and invasion pathways. Most stakeholders with an opportunity to manage silverleaf nightshade are farmers who need to make a profit. It is very important that an economic imperative is clearly demonstrated to farmers to motivate them to act. Best practice management information, delivered in an effective and targeted manner, will underpin effective on-ground management. A focussed and coordinated research portfolio will help to fill management knowledge gaps, and to explore biological control options. Support for this plan's goals and objectives and integration into regional and state legislation, policy and plans will help to strengthen commitment. Communication and monitoring will ensure that the plan is a "living", relevant, effective and dynamic document.

Objectives	Strategic Actions	Priority	Responsible Partners
3.1 Reliable distribution maps suitable to inform strategic management decisions are produced.	3.1.1. Collect state and regional SLN distribution data and collate into a national database (e.g. national mapping portal).	1	SLNNMC, researchers, NRM/CMA, LGA, S&T
	3.1.2. Produce current national distribution and strategic management action maps (e.g. eradication and containment zones).	1	National coordinator role, SLNNMC
	3.1.3. Collaborate with other WoNS projects to improve mapping systems.	2	National coordinator role, SLNNMC
	3.1.4. Review and revise potential distribution (risk) maps, considering land-use, soil-type and climate change.	2	SLNNMC, researchers
	3.1.5. Better define and manage the current and potential risk to horticultural and irrigated crops.	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, industry bodies, local action groups, landholders
3.2 Capability to manage SLN is increased by current best management practice tools, information, education and support for stakeholders.	3.2.1. Draft a national communication plan to guide information dissemination to stakeholders and identify delivery gaps.	1	National coordinator role, SLNNMC
	3.2.2. Develop, revise and distribute best practice management guide and identification guide, using multiple media.	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups
	3.2.3. Deliver latest information on SLN to land managers through a series of national and regional meetings to raise awareness, build capacity and encourage control efforts.	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups
	3.2.4. Promote management of SLN via regional electronic and print media, in collaboration with local stakeholders.	2	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups
	3.2.5. Provide ad-hoc advice and support to stakeholders on management of SLN.	2	SLNNMC, NRM/CMA, LGA, S&T

Objectives (cont.)	Strategic Actions	Priority	Responsible Partners
3.3 Willingness and motivation to manage SLN is increased by improved awareness and knowledge of its economic impacts, supported by case studies.	3.3.1. Review, summarise and publicise crop and pasture yield benefits from seasonal control of SLN, including protocols for on-farm measurement of control benefits.	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, industry bodies, local action groups, landholders
	3.3.2. Document case studies of SLN management experiences (outlier and large established infestations) and incorporate into best practice management guide.	2	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups, landholders
	3.3.3. Organise for key stakeholders from sparsely-infested regions to visit and discuss the implications with managers of large established infestations, including field examination of extensive infestations during summer.	1	SLNNMC, NRM/CMA, LGA, local action groups, landholders
3.4 Capability and willingness to manage SLN are increased by the formation of a SLN network and SLNNMC.	3.4.1. Consult widely amongst stakeholders and establish a regular communication strategy (e.g. email group, newsletter, national technical meeting) to exchange new information within the network.	1	National coordinator role, SLNNMC
	3.4.2. Establish a Silverleaf Nightshade National Management Group (SLNNMC) to oversee the implementation of the national SLN strategic plan.	1	National coordinator role.
	3.4.3. Collaborate and cooperate with other WoNS projects in collective activities to add value to the WoNS initiative.	2	National coordinator role, SLNNMC
3.5 Stakeholder capabilities and ownership are increased by encouraging research, development and local community projects.	3.5.1. Identify research gaps and liaise with research funders and research providers to facilitate relevant and focussed research activities (see 1.4 and 2.1).	1	SLNNMC, researchers, NRM/CMA, LGA, S&T, local action groups, landholders
	3.5.2. Encourage and support local and regional action/community groups to conduct research and demonstration projects to fill local knowledge gaps and encourage control efforts.	2	SLNNMC, researchers, NRM/CMA, LGA, S&T
3.6 Plans, policy and legislation at local to national jurisdictional levels incorporate or support the SLN strategic plan.	3.6.1. Review state and regional policies and legislation, and advocate for change to support the SLN strategic plan.	1	SLNNMC, NRM/CMA, LGA, S&T, local action groups, landholders
	3.6.2. State and regional agencies integrate relevant SLN strategic plan objectives into their operational plans.	1	S&T, SLNNMC
3.7 The SLN national strategic plan is relevant, effective,	3.7.1. Implement, monitor and review the national strategic plan.	1	National coordinator role, SLNNMC

and its implementation is supported by stakeholders	3.7.2. Develop a MERI process for the strategic plan and report progress of implementation to AWC and key stakeholders.	2	National coordinator role, SLNNMC
3. 8 Resilient long-term management of SLN is promoted through establishment of enduring structures, capabilities and resources.	3.8.1. Engage a core, regionally-based group of long-term advocates for SLN management in the planning and implementation of the national SLN strategic plan.	1	SLNNMC, researchers, NRM/CMA, S&T, local action groups, landholders
	3.8.2. Consider SLN WoNS phase transition processes and implications in all planning activities.	2	SLNNMC, NRM/CMA, S&T
	3.8.3. Ensure that a comprehensive knowledge resource on SLN is available from within stable long-term structures (e.g. www.weeds.org.au).	1	SLNNMC, researchers, NRM/CMA, S&T

4 STAKEHOLDER ROLES AND RESPONSIBILITIES

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

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

Australian Government

- Ensure quarantine controls to prevent importation (DAFF Biosecurity).
- Promote the status of silverleaf nightshade as a WoNS, its impacts and the importance of management.
- Undertake strategic silverleaf nightshade control on all Australian government managed lands.

Australian Weeds Committee

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

Silverleaf Nightshade National Management Group (or similar taskforce)

- Ensure a diversity of community and agency views are represented for effective strategy implementation.
- Provide guidance, direction and policy advice for the management of silverleaf nightshade through the delivery of the strategic plan.

- Monitor, evaluate, report and improve strategy implementation.
- Assist in the development and implementation of programs and initiatives which support strategic actions.
- Maintain and build partnerships with key stakeholders to improve strategic silverleaf nightshade management.
- Identify funding sources and provide independent advice for prospective applicants for projects consistent with the needs of the WoNS strategy.

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

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

State and territory agencies

- Maintain appropriate legislation and policies to achieve state and territory based objectives for managing silverleaf nightshade.
- Administer and enforce legislation where applicable.
- Coordinate silverleaf nightshade control and management at a jurisdictional level to foster the delivery of the silverleaf nightshade National Strategic Plan.
- Manage and control silverleaf nightshade on public lands in accordance with State/Territory or local government legislation, policy and best practice.
- Work with regional bodies, local governments, communities and other stakeholders to prevent and minimise silverleaf nightshade impacts.
- Identify strategic management areas and associated objectives.
- Promote consistency with this Strategy in jurisdictional pest management plans.
- Facilitate the inclusion of strategic silverleaf nightshade management actions in pest management planning processes.
- Contribute to priority research initiatives.
- Source funding for strategic management programs and research.
- Implement monitoring and reporting in line with the MERI plan and provide relevant information to the national taskforce and/or Australian Weeds Committee.
- Develop and implement communication plans and extension tools, where appropriate.
- Undertake any necessary planning and mapping and contribute to national mapping initiatives.
- Ensure, where appropriate, participation on the National Silverleaf Nightshade Management Group or similar national taskforce.
- Improve knowledge of the identification, impacts and best practice management of silverleaf nightshade.
- Identify silverleaf nightshade and other weeds threatening public lands.
- Implement weed hygiene and other best practice management to minimise spread of silverleaf nightshade.

Natural Resource Management regions (or Catchment Management Authorities)

- Incorporate silverleaf nightshade objectives in relevant pest management plans and monitor implementation.
- Administer and enforce legislation where applicable (e.g. in SA).
- Source funding and/or contribute to strategic control programs.
- Improve regional awareness of impacts and identification; and promote early detection.

- Participate in regional mapping initiatives and contribute to state, territory and national map production.

Local governments

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

Industry

- Promote and adopt best practice management of silverleaf nightshade.
- Identify gaps and issues associated with implementation of silverleaf nightshade national strategy.
- Contribute to research and development of management practices to support industry members.
- Ensure awareness of sale and movement restrictions of silverleaf nightshade within industry members (including National Livestock Identification Scheme (NLIS)).
- Improve community awareness of impacts and identification, and promote early detection.

Private land owners

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

5 MONITORING EVALUATION REPORTING AND IMPROVEMENT

MERI is the system endorsed by the Australian Government for monitoring, evaluating, reporting and improving natural resource management projects. Monitoring and evaluation of measurable outcomes will identify problem areas and lead to improvements to the plan. Reporting of progress against the plan will help to maintain ongoing funding and stakeholder enthusiasm. Some of the objectives that contribute to achieving goals are already undertaken on an on-going basis, and this good work by stakeholders should be acknowledged in base-line measurements. Implementation of this plan should add new activities and accelerate existing activities.

The AWC has been assigned the task of monitoring and evaluating the management of national priority weeds (including WoNS) on behalf of the AWS (Natural Resources Management Ministerial Council, 2006). This plan relies on State and regional NRM/CMA agencies to contribute to monitoring and evaluation of the plan. A silverleaf nightshade national management group (SLNNMC) is proposed to be formed to implement the strategic plan and to report annually to the AWC. The MERI process is particularly important for Goal 1 (prevention), and for externally-funded activities. Monitoring data will be collected by targeted surveys, questionnaires, and stakeholder consultation.

The draft table below (5.1) will form the basis for the silverleaf nightshade MERI process and guide work plans. Other information and data sources may be added on an ad-hoc basis**.**

5.1 Targets and Measures

Strategic Plan Goals	Key Evaluation Questions	Data/Evidence Required	Consider
1. New infestations are prevented from establishing.	To what extent have new infestations been prevented from establishing?	<u>1.1National distribution data</u> • 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/info stored? • Do they capture national priorities?
		<u>1.2 New infestations</u> • Number of new outlier infestations[1] recorded. • Percentage of known infestations actively controlled. [1] New infestations should be an outlier, outside existing distribution of WoNS	• Are any new outlier 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? And threats minimised?
		<u>1.3 Eradication & containment programs</u> • 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? • Can include examples using case studies.

		1.4 Legislation • Have there been any legislation or policy changes for this species? • Has a need for legislative change been identified by stakeholders?	• Are minimum requirements being maintained (e.g. ban on sale, trade, movement? • Is control required throughout or in part of jurisdiction? • Is compliance actively enforced?
		Overall progress rating	
2. Existing infestations are under strategic management.	To what extent is integrated weed management effectively managing core infestations?	2.1 Integrated Weed Management • How effective are IWM programs?	• Are existing tools providing adequate control of WoNS? • Have new advances/technologies been developed and are they incorporated into BPM 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 (eg assessed against relevant Threat Abatement Plans)? • Percentage of state/regional invasive species plans that identify priority assets at risk from WoNS?	• Response should include status report on progress towards asset protection programs. • 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?
		Overall progress rating	
3. Greater capability and commitment to	To what extent has the capability and commitment to manage WoNS	3.1 Community engagement & awareness • What is the status of best practice information?	• Is best practice information up to date and readily available? • Is this information and/or advice being targeted to

manage WoNS.	increased?	• Are partnerships being maintained to ensure collaboration on WoNS? • Number and type of media activities.	priority regions. • Is training being delivered to meet the needs of weed managers (including the community)? • Are networks/groups being supported (e.g. through dissemination of research outcomes, 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 Commonwealth, jurisdictions, industry, etc
		3.3 Policy & Planning • Are the objectives of the strategy being integrated into commonwealth/state/regional plans, policies and programs? • Has cross border collaboration occurred?	• How are priorities reflected in planning and policy approaches? E.g. WRA, invasive species plans, asset protection plans, district plans, weed spread prevention activities, management programs, incentive programs, state working groups. • How are national priorities being maintained? E.g. containment lines, eradication targets, training & awareness raising, research projects.
		Overall progress rating	
Continuous improvement	Are there any unexpected outcomes that have been identified through implementation of strategy?	4.1 Barriers • Have any other management issues or impediments been identified?	

How to score progress rating

1- Insufficient evidence to score

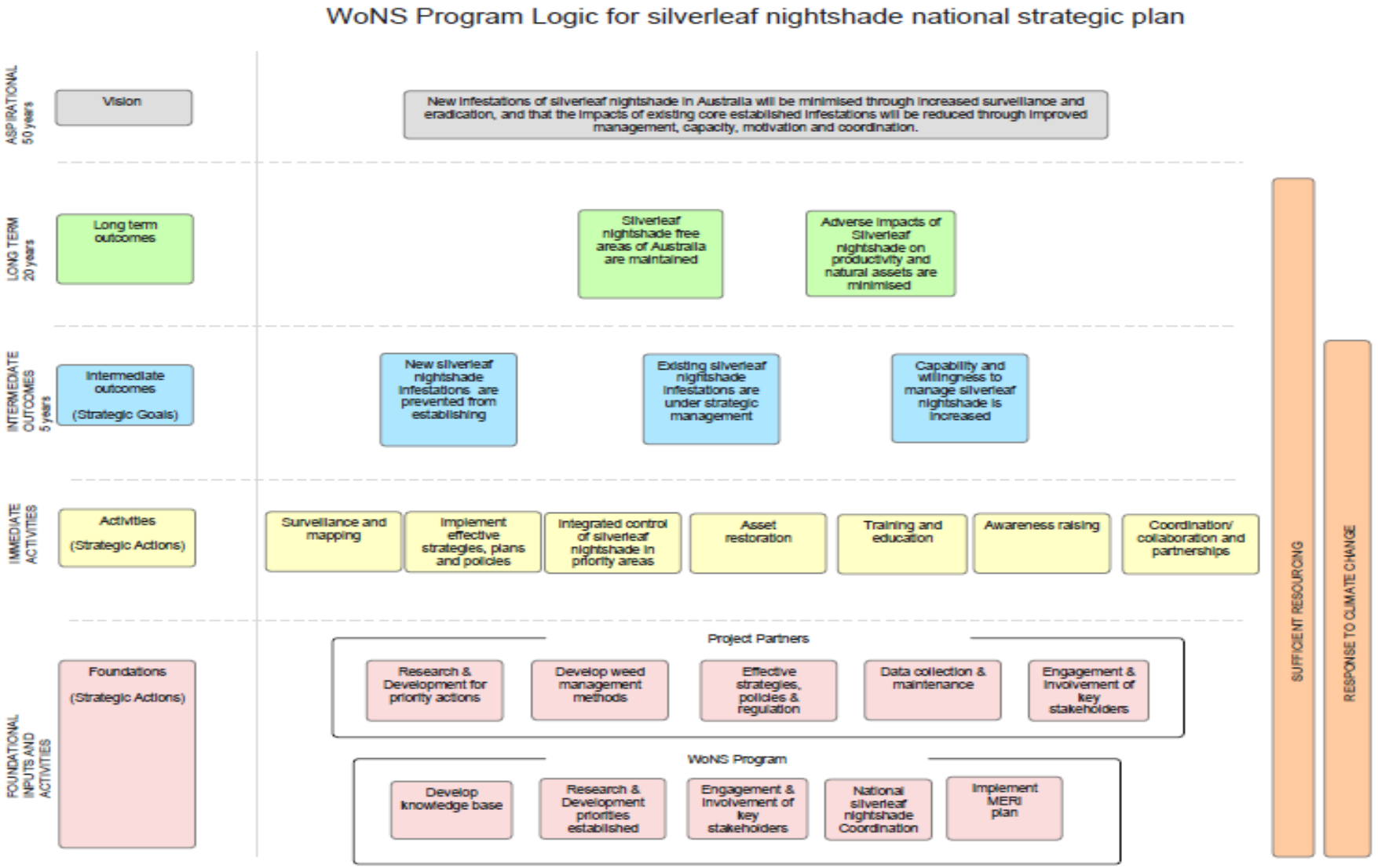
2- No progress against goal

3- Limited progress is being made against this goal

4- Reasonable progress is being made against this goal

5- Excellent progress is being made against this goal

5.2 Program Logic Model



6 Technical Background

A detailed technical background on silverleaf nightshade in Australia was published in a major review by Heap and Carter (1999), which has since been updated by Stanton *et* al. (2009). Further details can be found in these publications.

6.1 Silverleaf nightshade identification

Silverleaf nightshade is sometimes confused with two native Solanum species in Australia, native quena (*S. esuriale* Lindl.) and western nightshade (*S. coactiliferum* J.M. Black). Silverleaf nightshade has a taller, more robust habit, and longer leaves (10 cm cf. 5 cm) than *S. esuriale*, with more wavy margins (Cuthbertson and Leys 1976, McKenzie 1976a). *S. coactiliferum* grows in sandy soils as a relic of native vegetation and is not normally an aggressive weed (D.E. Symon pers. Comm.). *S. karsensis* (Symon), a native perennial that infests irrigated crops in far western New South Wales, is also similar in appearance and behaviour to silverleaf nightshade (Monaghan and Brownlee 1981).

There is morphological variability within Australian populations for degree of spininess, growth habit, petal colour and leaf shape, size and lobing, but the variation is considered to be within the range of the species. The variability is probably the result of multiple introductions, rather than hybridization with related indigenous species (Tideman 1960a, Leys and Cuthbertson 1977). Recent genetic analysis of populations in South Australia provides support for multiple importation events based on the large genetic diversity observed between populations (Hawker *et al.* 2006). Recent genetic studies suggest that there may be two major genetic blocks (centred in SA and NSW) that have intermingled (Xiaocheng Zhu, pers. comm., 2012).

6.2 Silverleaf nightshade biology and ecology

Silverleaf nightshade is adapted to a wide range of habitats, a characteristic that contributes to its weediness in diverse regions in Australia, and around the world. It grows in the warm, temperate regions of Australia with an annual rainfall of 250–600 mm, and grows in a range of soil textures (Parsons and Cuthbertson 1992), although the heaviest infestations occur on sandy soils with low organic matter (Leys and Cuthbertson 1977). The largest infestations are on cropping and grazing land, with smaller infestations being found in irrigated pastures, orchards and vineyards, roadsides, channel banks and stockyards (McKenzie 1980). It does not normally invade undisturbed pastures, although this has been observed in South Africa (Wassermann *et al.* 1988). Cool summers and high annual rainfall may limit its distribution in some regions of Australia (Panetta and Mitchell 1991). Silverleaf nightshade is sensitive to frost and highly resistant to drought (Wassermann *et al.* 1988).

The deep, perennial root system confers drought-resistance (Wassermann *et al.* 1988) and resists most control strategies. Roots have been measured to a depth of 4 m in Australia (D. Creeper pers. comm.) and consist of three main parts: the main or vertical tap root, the portion of the shoot extending from the main tap root to the soil surface, and the lateral structure that connects adjacent shoots. Secondary shoots grow up to 2 m horizontally before turning downwards (Cuthbertson 1976). Total non-structural carbohydrate (TNC) levels are an indication of stored energy reserves and plants are thought to be less able to survive herbicide damage when TNC levels are low. TNC levels are lowest at flower bud formation and then build up between flowering and fruit maturation (Bouhache *et al.* 1993).

New shoots develop from buds on the roots in late spring and are killed by frosts during late autumn or early winter. Shoots emerge from perennial roots in October to November in Australia and flowering commences in December, about three weeks after shoot emergence (Moore *et al.* 1975), and continues through to February or March. The first fruits normally form in January and berries ripen and seeds mature about 4 to 8 weeks after fruit set (McKenzie 1980). Flowering and fruiting continue through summer and autumn while conditions are suitable. Each stem produces about 60 berries per season in Australia, with each berry containing about 50 seeds (Cuthbertson and Leys 1976). There were 4000 seeds m^{-2} in the top 10 cm of soil in a dense infestation in north-western Victoria (McKenzie 1980).

Factors controlling germination and seedling establishment of silverleaf nightshade are poorly understood. Seeds have a strict germination requirement for alternating temperature (McKenzie and Douglas 1974, Boyd and Murray 1982, Trione and Cony 1990). Optimum conditions for germination in Oklahoma were 20/30°C for 16 h dark/8 h light (Cooley and Smith 1972), and seeds will germinate equally in light or dark (McKenzie and Douglas 1974, Boyd and Murray 1982, Vigna *et al.* 1983, Trione and Cony 1990). Only occasionally are high numbers of seedlings observed in Australia, suggesting specific moisture and temperature requirements for germination. Seeds of silverleaf nightshade germinate after heavy rains in spring to early autumn, with alternating cool and warm temperatures. Emergence occurs more in disturbed soils than on crusted,

compacted or undisturbed soil (Cuthbertson and Leys 1976). Ingestion and excretion of seed by sheep increases germination (Parsons and Cuthbertson 1992). Seedlings are rarely observed in the Australian Mallee due to dry summers (McKenzie 1980). Most seedlings germinate after heavy summer thunderstorms, and survival depends on continued soil moisture during summer in Victoria (Molnar and McKenzie 1976). Following 75 mm of rain in the Mallee in 1973, seedlings were abundant, but few survived to the next growing season (McKenzie 1980). In Australia, seedlings that emerge in summer are usually killed by heat and drought, and those that emerge in late autumn are probably killed by frost. In regions with significant warm season rainfall, such as in its native range, seedlings are sustained by late spring and summer rainfall and are not normally subjected to frost (Wapshere 1988).

6.3 Silverleaf nightshade distribution and spread

There is some evidence that silverleaf nightshade evolved in the Monterrey region in north-eastern Mexico, based on an assessment of the variation, distribution and frequency of its naturally occurring herbivores (Wapshere, 1988). Many of the regions of the world where silverleaf nightshade has established have similar climates to this putative area of origin. It has spread to many countries, and has become a major problem in Australia, Argentina, Greece, India, Morocco, North America and South Africa (Carretero 1989, Holm *et al.* 1991, Parsons and Cuthbertson 1992, Eleftherohorinos *et al.* 1993).

Silverleaf nightshade was first reported in Australia at Bingara (northern New South Wales**)** in 1901, but the route of introduction is not known. Infestations were then recorded at Tenterfield (1907), North Melbourne (1909), Singleton (1914), Hopetoun (1918) and Cowra (1923) (Cuthbertson and Leys 1976). Silverleaf nightshade now occurs in South Australia, New South Wales, Victoria, Western Australia and southern Queensland. It is a serious weed in South Australia, New South Wales and Victoria, with large infestations occurring throughout the cereal cropping zones. Isolated infestations occur in Queensland and Western Australia.

In South Australia, it occurs throughout the cereal cropping zones and is causing most concern in parts of the Upper South East, Mallee, Lower and Mid-North, and Eastern Eyre Peninsula regions. It was first recorded in South Australia in 1914 (Kloot 1986), possibly arising from contaminated hay from the USA (Parsons and Cuthbertson 1992), and was recognized as a potentially serious weed by the late 1940s. All infestations were thought to be *S. esuriale* until 1958, when it was realized that silverleaf nightshade was also present. By 1978, South Australia had about 16,000 ha (J. Dickenson pers. comm.) and by 1990 the area exceeded 40,000 ha (South Australian Animal and Plant Control Commission survey, unpublished).

In NSW it infests large areas of the southern and central wheat zone, the north-western slopes, and the Murrumbidgee Irrigation Area (Lemerle 1983), with an estimated 140 000 ha affected in 1992, a seven-fold increase since 1977 (Dellow 1993, Hennessy 1995).The weed was of little importance until 1960 when a series of wet summers accelerated spread (Cuthbertson and Leys 1976).

In Victoria silverleaf nightshade was first declared under noxious weed legislation in 1950 (McKenzie 1980) and by 1973 the State had an estimated 1000 ha, with 90% occurring on six farms (Parsons 1973). Infestations occur throughout the Wimmera and Mallee regions in the west and north of Victoria. The worst-affected areas are around Mildura, Hopetoun, Horsham and Pyramid Hill (Anon. 1980).

In Western Australia it was first found in 1950 and is established at more than 50 sites in a band running from Perth south-east to Albany. Risk assessment shows that it is established only over a small proportion of its potential high and medium risk distribution areas (Connell and Panetta 1993). It was made a declared plant in Western Australia in 1973 (Rutherford 1978) and removed from the declared plant list in the late 1990s (S. Lloyd pers. comm.). By 1978 it covered 150 ha, although only 17 ha of this area was densely infested. It probably arrived in Western Australia before 1921, possibly in Sudan grass (*Sorghum sudanense*) from eastern Australia (P.A. Rutherford pers. comm.).

Based on experience from North America, the weed has the potential to spread to, and have a major impact on, the summer cropping areas of Australia, especially in the cotton production areas of northern New South Wales and southern Queensland (G.W. Charles pers. comm. 1997). A low rate of dispersal, due to the near absence of livestock, may be the reason that it is not yet a major problem in these areas. If summer cropping expands from these areas southwards into silverleaf nightshade infested land, then the potential for seed spread as a contaminant of harvested produce will increase (R. Stanton, pers. comm.).

Seeds can be dispersed by water, birds, vehicles, machinery and animal faeces (McKenzie 1980, Heap and Honan 1993), as well as infested fodder and seed (Cuthbertson and Leys 1976). Dry berries can spread rapidly over long distances in streams in South Africa (Wassermann *et al.* 1988) and there is strong evidence

that this also occurs in Australia. Mature shoots can tumble across the ground when blown by wind, thus spreading berries (Parsons 1973).

Sheep readily eat berries in Australia and they appear to be the main vectors (Fig. 4). In field studies with sheep in South Australia, excretion began within 24 hours of ingestion and most seeds were excreted within 7 to 9 days. There were up to 672 seeds kg^{-1} of fresh dung. A 14 day quarantine period was suggested, where practical, although single seeds were detected 17 and 31 days after ingestion. Mature berries (on stalks and on the ground) and green berries were eaten to exhaustion between January and April (mid-summer to mid-autumn) when alternative feed supplies were low. Much of the excreted seed is viable (Heap and Honan 1993).

Figure 4. Seeds (top left) spread in sheep dung to produce seedlings (top right) - this is a major invasion pathway for silverleaf nightshade.

Silverleaf nightshade has a deep, robust tap-root that grows to 3 to 4 m deep. Robust lateral roots branch off from the main tap-root 15 to 30 cm below the surface, and give rise to daughter shoots 40 to 60 cm from the parent plant (Dittmer, 1959). It is clear that vegetative reproduction contributes to spread, primarily through clonal root growth at the margins of colonies, but transport of fragments during cultivation can also occur (Fig. 5). Large patches of recognizable forms, sometimes isolated, and sometimes interspersed with other forms, indicate extensive clonal spread by root growth in Australia (D.E. Symon, unpublished report). Recent studies suggest that transported stem fragments may also be viable propagules (Xiaocheng Zhu, pers. comm., 2012). Regenerating crowns and lateral roots were observed to arise from as deep as 50 cm in cultivated soils, compared with 1 to 20 cm for uncultivated soils (Monaghan and Brownlee 1979). Grazed colonies increase in diameter by an average of 70 cm per year and the rate of expansion varies greatly with season. In one wet year, colony diameter increased by 3.9 m and in a dry year it decreased by up to 2 m (McKenzie 1980).

Figure 5. Root and shoot fragments can be dragged by cultivation equipment to initiate new patches in seasons with suitable soil moisture conditions (Photo courtesy of Dr. Rex Stanton).

6.4 Summary of impacts

General. Silverleaf nightshade competes with crops, exudes plant inhibitors, interferes with animal husbandry and harvesting practices, and is an alternative host for plant eating-insects and plant diseases (Boyd *et al.* 1984). It can reduce management options, such as the use and value of land, and sale of hay (McKenzie 1980). In the 1970s, landowner concern about further spread in Victoria was very strong (McKenzie 1976b), and the greatest economic effect of silverleaf nightshade in eastern Australia was the reduction of land values for both infested and nearby properties (McKenzie 1980, Moore *et al.* 1975).

Crops. Silverleaf nightshade competes for water and nutrients in dryland and irrigated crops, and soil moisture losses have been measured at depths of up to 150 cm (Green *et al.* 1988). It competes indirectly with winter crops and pastures through moisture and nutrient depletion during the summer fallow period (Cuthbertson and Leys 1976). Yields of dryland crops are reduced over most of its range and this appears to be most severe in sandy soils and seasons with low rainfall. The greatest unrealized threat to Australian agriculture is widespread invasion of summer-irrigated land (Leys and Cuthbertson 1977).

Yield experiments at 11 sites in 1977 on the Eyre Peninsula, South Australia, and in New South Wales measured cereal yield reductions of 4 to 77% (mean 41%), with the largest loss occurring in low rainfall, sandy sites (J. Dickenson pers. comm.). Estimated maximum yield reductions in cereals in South Australia at five sites in 1990 ranged from 0 to 55%. Yield reductions were also highest at dry, sandy sites with low rainfall (J. Heap, unpublished data). Research in Victoria suggests that wheat yield can be reduced by up to 50% when infested by silverleaf nightshade, but this varied greatly with seasonal conditions and weed density (McKenzie 1980). Wheat yields at eight sites in the Victorian Mallee were measured over three years in areas with shoot densities between 1.5 and 17.1 plants m^{-2}. Yield reductions ranged from 11 to 43%, with an average of 36% (Molnar 1982). A moderate infestation of nine plants m^{-2} in New South Wales reduced grain yield by 12%. Yield losses were most pronounced in low rainfall years when crops relied more heavily on sub-soil moisture (Cuthbertson and Leys 1976). When silverleaf nightshade was controlled with 2,4-D or glyphosate in New South Wales prior to sowing wheat, yield increases ranged from nil to 69% on a clay-loam soil. The largest increases were recorded in a drought year when moisture limited yield (Lemerle and Leys 1991).

Pastures. Silverleaf nightshade competes directly with summer-growing pastures such as lucerne, and occasionally dense infestations restrict access to pasture underneath dense canopies. There is also evidence that annual winter pastures are affected by delayed autumn emergence and lower production, leading to reduced carrying capacity (Cuthbertson and Leys 1976, McKenzie 1980). Glycoalaloids produced

by silverleaf nightshade may be hydrolysed in the gut to form nerve toxins such as alkalids or alkamines. Sheep are more resistant to the toxins than cattle, and goats are unaffected (Boyd *et al.* 1984). In Australia, significant and obvious acute poisoning of livestock appears to be rare. Accounts of palatability are varied and somewhat contradictory. Sheep will readily eat foliage and berries when pasture reserves are low (McKenzie 1980). Silverleaf nightshade is reported to be unpalatable and generally avoided by stock in Victoria and southern New South Wales, although the fruits are apparently attractive to grazing sheep, which have also been observed grazing buds and flowers (D.E. Symon, unpublished 1975).

Beneficial aspects. Although its significance is overwhelmingly as a weed, several potentially beneficial attributes have been identified for silverleaf nightshade. It contains the glycoalkaloid solasodine, which is a precursor for the manufacture of pharmaceuticals such as corticosteroids. The use of silverleaf nightshade as a potential pharma crop for the production of solasodine has been investigated in Argentina and India (Kaul and Zutshi 1973, Chiale *et al.* 1991). It also has activity against cultured melanoma cell lines (Sathiyamoorthy *et al.* 1999), has potential pesticidal properties (Bekkouche *et al.* 2000; Markouk *et al.* 2000), and may be useful for bioremediation (Tiemann *et al.* 2001).

6.5 Control options

6.5.1. Prevention

Prevention is the most cost-effective method to control weeds, including silverleaf nightshade. There is currently no practical way to eradicate large infestations once they are established. Critical to success is the identification and management of propagule sources, vectors, and key invasion pathways. Smith (1975) mapped the distribution of silverleaf nightshade in South Australia and proposed a control strategy to limit spread. Carter (1992) demonstrated that co-ordinated control programs involving publicity, extension and enforced control reduced the rate of spread of silverleaf nightshade in the Eyre Peninsula region of South Australia. The study highlighted the need to detect new infestations early and to ensure that they were controlled, rather than concentrating on large, established infestations.

6.5.2. Chemical control

Silverleaf nightshade is a major weed in many countries and over the decades a wide array of herbicides has been screened for efficacy. Research into chemical control dates back to at least 1937, when carbon bisulphide was used as a soil sterilant (Davis *et al.* 1945). Although there have been instances of success, there are few weeds which have withstood the onslaught of chemical research as well as silverleaf nightshade. Some herbicides will control seedlings and established plants as a spot-spraying treatment, but there are so far no suitable treatments for control of large, established infestations. In the absence of such a treatment, the general aim should be to contain and suppress large infestations and to eradicate small patches and colonies (Cuthbertson and Leys 1976). The exceptional root development of silverleaf nightshade is the reason that it is so difficult to control with herbicides. Chemical control is made more difficult by the range of crops and environmental conditions encountered, including the effect of residual herbicides on following crops.

A herbicide that is easily absorbed and very effectively translocated is required to kill the whole root system (Richardson and McKenzie 1981). The three most significant herbicides identified for use on established core infestations to date are 2,4-D, picloram and glyphosate. McKenzie (1980) observed that herbicide experiments should not be assessed too early because silverleaf nightshade has remarkable abilities to recover, and often emergence in sprayed plots in the following season is merely delayed. Molnar (1982) concluded from the results of 32 field experiments over six years in the Victorian Mallee that 2,4-D ester at 1.2 kg a.i. ha^{-1} was the most effective treatment for short-term suppression of flowering and seedset, and that picloram/2,4-D gave the most consistent long-term control.

Picloram is most commonly used to treat small infestations of silverleaf nightshade, with the aim of eradication, because it remains active in the soil for several years and is moved down the soil profile with wetting fronts. It is often used in a mixture with 2,4-D, which gives rapid control of shoot growth, and residual control of regrowth. Spraying shoots and soil for a radius of 2 m was much more effective than treating only shoots (McKenzie 1980). Picloram is not suitable for treating large areas due to cost and the detrimental effect on following broad-leaved crop and pasture species. Tebuthiuron also has potential as an eradication treatment.

2,4-D is used to suppress shoot growth and to reduce flowering and seed set in silverleaf nightshade but there is little evidence that roots are damaged. Two to four applications are needed over the six month growing season (McKenzie 1980). Fluroxypyr has potential to be used in a similar way.

Glyphosate gives variable control of silverleaf nightshade in Australia, but results in some other countries are good. Timing of herbicide application can be important, and efficacy is probably determined by factors such as drought stress, dustiness of leaves, air humidity, and growth stage. Spot treatments are used at 3.6 to 7.2 g a.i. L^{-1}. Under dry Mallee conditions, glyphosate was not effective, with regrowth and seed set occurring frequently after treatment (McKenzie 1980).

Some other herbicides with reported efficacy against silverleaf nightshade include bromacil, clopyralid, ethidimuron, fluoroxypyr, hexazinone, imazapyr, karbutilate, tebuthiuron and terbacil (Molnar 1982, Bouhache *et al.* 1993, and G.M. Fromm pers. comm.). Tebuthiuron was applied in South Africa at 2 to 6 kg a.i. ha^{-1} without complete control (Wassermann *et al.* 1988) but at one site in Australia, 4 kg a.i. ha^{-1} gave over 99% control six years after application (J. Heap, unpublished data). Aminopyralid is a new pyridinecarboxylic acid herbicide (Group I) in Australia that has both foliar and soil residual activity. This herbicide has been shown to provide greater than 96% control of tropical soda apple (*Solanum viarum*) populations when applied at rates above 60 g a.i./ha (Ferrell *et al.* 2006).

Large, established infestations of silverleaf nightshade are sometimes sprayed as the primary target, but they are more frequently sprayed during broader summer weed control programs that target a range of species. A particular problem is the reluctance of share croppers (land leasers) to spend money on silverleaf nightshade control when there is no short-term incentive for them to do so. Infestations on roadsides and railway lines are also often untreated when there is little or no external pressure to comply with legislated requirements. Recent research by NSW DPI suggests that two treatments per season may improve control of established infestations. The first treatment (2,4-D or glyphosate) is aimed at preventing seed-set, while a second treatment (picloram) is aimed at controlling the root system (H. Wu, pers. comm.).

6.5.3. Biological control

The inability of cultural or chemical methods to control established core infestations of silverleaf nightshade has made it a major candidate for biological control in many countries, including the USA, South Africa and Australia. There have been extensive searches for agents in western and central USA but so far no agents suited to Mediterranean regions have been found. In a survey of the USA, 22 insect species were found on silverleaf nightshade in California, on the extremities of the plant's range, and 90 species in Texas, part of the probable centre of diversity for the species (Goeden 1971).

It was recognized during the 1970s that there was a case for direct Australian participation in biological control investigations (Moore *et al.* 1975). There have been periodic reports of a range of native organisms attacking shoots and roots of silverleaf nightshade in Australia, but so far none has been explored beyond initial investigations. The two most important aspects for selection of potential agents are the absence of silverleaf nightshade aerial vegetation from late autumn to spring, and regeneration primarily from established rootstocks. Most agents identified in Central America would be severely limited by cultivation associated with crop production at the time, but it should be noted that cultivation intensity has reduced significantly since this observation was made. No agents that attacked roots were detected. It is concluded that the summer drought which occurs in most areas infested in Australia would not be suitable for the agents found in Central America. However, some regions in northern New South Wales and southern Queensland which receive reliable summer rainfall may support some promising species (Wapshere 1988). Similarly, Goeden (1971) concluded that transfer of agents from Central America to regions of California with a Mediterranean climate would be unlikely to succeed.

Wassermann *et al.* (1988) concluded that unless an extremely effective herbicide became available, biological control should be given serious attention in South Africa. Silverleaf nightshade has virtually no natural enemies in South Africa. A range of eight agents has been evaluated there since 1972, but most of these have been rejected due to lack of specificity or rearing problems. Two defoliating beetles, *Leptinotarsa defecta* and *L. texana*, have been identified as natural pests of silverleaf nightshade (Cuda *et al* 2002), and have been evaluated as potential biocontrol agents in South Africa, with releases occurring in 1992. *L. defecta* has not established viable populations, however *L. texana* has flourished and has suppressed silverleaf nightshade populations. Infested populations exhibited significant decreases in biomass and berry production when *L. texana* was present, although the studies did not indicate whether the damage inflicted would reduce the vigour of the root system to the point of preventing regeneration. Establishment has been predominantly in non-crop areas, where plants are not disturbed by herbicide application or cultivation. This is the first time that biological control agents have been successfully released against a member of Solanaceae anywhere in the world (Hoffman et. al. 1998, Olckers *et al.* 1996, Olckers 1997).

Kwong et al (2008) concluded that the central regions of Argentina and Chile should be explored for potential agents, because the climatic conditions there are more closely matched to southern Australia than those of

found in central America. They also encouraged more research on the taxonomic relationships between Australian material and that of central and South America.

6.5.4. Physical and other control options

Practical results from cultivation and slashing in Australia have been poor. Limited success has been observed using competition from perennial species, and allelopathy from some *Eucalyptus* species. Vigorous pastures, especially those based on perennial summer-growing species, can significantly suppress silverleaf nightshade growth (R. Stanton and B. Thompson, pers. comm.). Cultivation is reported to be ineffective in Australia because most of the roots are below the depth of cultivation and new plants may establish from transplanted fragments. In Australia, the combination of slashing or cultivation and herbicide application did not improve control above the level of 2,4-D or picloram/2,4-D treatments alone (McKenzie 1980). In Argentina it is suppressed by intensive cropping (wheat-sorghum-wheat rotation), and the competitiveness of *Eragrostis curvula* in sown pastures (Amor 1977). Demonstration trials in SA and NSW suggest that several *Eucalyptus* spp. have some ability to control silverleaf nightshade growth within the canopy drip-line (B. Thompson, pers. comm.).

6.6 Quarantine and legislation

Silverleaf nightshade is listed as a noxious weed across most of New South Wales, Victoria and South Australia. A summary, based on information from www.weeds.org.au, and updated with information from State websites, is given in Table 3 below.

In New South Wales, silverleaf nightshade is declared as a Class 3 noxious weed in the north eastern parts of the state and a Class 4 noxious weed in the central and southern parts of the state, as described under the *Noxious Weeds Act, 1993*. The Act states that Class 3 noxious weeds are to be fully and continuously suppressed and destroyed. The growth and spread of Class 4 noxious weeds must be controlled according to the measures specified in a management plan published by the Local Control Authority.

In Victoria, silverleaf nightshade is declared as a Regionally Prohibited Weed in the Glenelg-Hopkins and Port Phillip Catchment and Land Protection (CaLP) regions, and a Regionally Controlled Weed in the Mallee, North Central, Wimmera, Corangamite, Goulburn Broken, and North East CaLP regions. It is also declared as a Restricted Weed in the East and West Gippsland CaLP regions. Noxious weeds are declared under the Catchment and Land Protection Act 1994, which states that Regionally prohibited weeds are not widespread and must be fully destroyed or controlled. Regionally controlled weeds are generally more widespread and land managers must prevent spread of the plant.

In South Australia, silverleaf nightshade is declared as a notifiable weed throughout the state under the *Natural Resources Management Act 2004*. Plants must be controlled and trade and movement are prohibited throughout the state. In Western Australia it is currently not declared but this may be reviewed. In Tasmania it is a noxious weed that is prohibited from introduction to the State and, if found, must be eradicated. It is not a declared weed in Queensland, Northern Territory or ACT.

Table 3. Legislative status of silverleaf nightshade in Australian states and territories.

(Source: http://www.weeds.org.au/noxious.htm (June, 2012), with additional information from State websites).

State/Territory	Legislation	Declaration	Goals/Action
Queensland	*Land Protection (Pest and Stock Route Management) Act 2002*	Not declared	Not declared
New South Wales	*Noxious Weeds Act 1993*	C3 (8) C4 (36)	Regionally controlled weed in 8 local control authorities Locally controlled weed in 36 local control authorities
Northern Territory	*Weeds Management Act 2001*	Not declared	Not declared

Western Australia	*Agriculture and Related Resources Protection Act 1976* *Plant Diseases Act 1914* From 2013 the *Biosecurity and Agriculture Management Act 2007* will be the principal legislation for the management of declared organisms in Western Australia	Not declared	Declared in the past, but not at present.
South Australia	*Natural Resources Management Act 2004*	2N@	Class 2: State-wide control required; trade and movement prohibited; reportable in at least some regions.
Victoria	*Catchment and Land Protection Act 1994*	P2 C6 R2	Regionally prohibited weed in 2 regions Regionally controlled weed in 6 regions Regionally restricted weed in 2 regions
Tasmania	*Weed Management Act 1999*	D	Declared
ACT	*Pest Plants and Animals Act 2005*	Not declared	Not declared

7 Appendices

7.1 Weed control contacts

State / Territory	Department	Phone	Email	Website
ACT	Environment and Sustainable Development Directorate.	132281	environment@act.gov.au	www.environment.act.gov.au/environment
NSW	Biosecurity NSW, NSW Dept of Primary Industries	1800 680 244	weeds@industry.nsw.gov.au	www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds
NT	Dept of Natural Resources, Environment, The Arts and Sport	08 8999 4567	weedinfo.nretas@nt.gov.au	www.nt.gov.au/weeds
QLD	Biosecurity Queensland, Dept of Employment, Economic Development and Innovation	132523	callweb@dpi.qld.gov.au	www.biosecurity.qld.gov.au
SA	Biosecurity SA, Dept of Primary Industries and Regions SA	08 8303 9620	nrmbiosecurity@sa.gov.au	www.pir.sa.gov.au/biosecuritysa/nrm_biosecurity
TAS	Dept of Primary Industries, Parks, Water and Environment	1300 368 550	Go to www.dpipwe.tas.gov.au/weeds , scroll to the bottom of the page and click on “weeds enquiries”	www.dpipwe.tas.gov.au/weeds
VIC	Dept of Primary Industries	136186	customer.service@dpi.vic.gov.au	http://new.dpi.vic.gov.au/agriculture/pests-diseases-and-weeds
WA	Dept of Agriculture and Food	08 9368 3333	enquiries@agric.wa.gov.au	www.agric.wa.gov.au
National	Australian Pesticides and Veterinary Medicines Authority	02 62104701	contact@apvma.gov.au	www.apvma.gov.au

7.2 The WoNS initiative and its phases

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

Following the reviews, the Natural Resource Management Ministerial Council (Resolution 15.7, 21 May 2009) endorsed a three-phased approach to national management of WoNS species (Fig. 6). This 'phased approach' aims to provide the most cost-effective use of limited 'national coordination' resources.

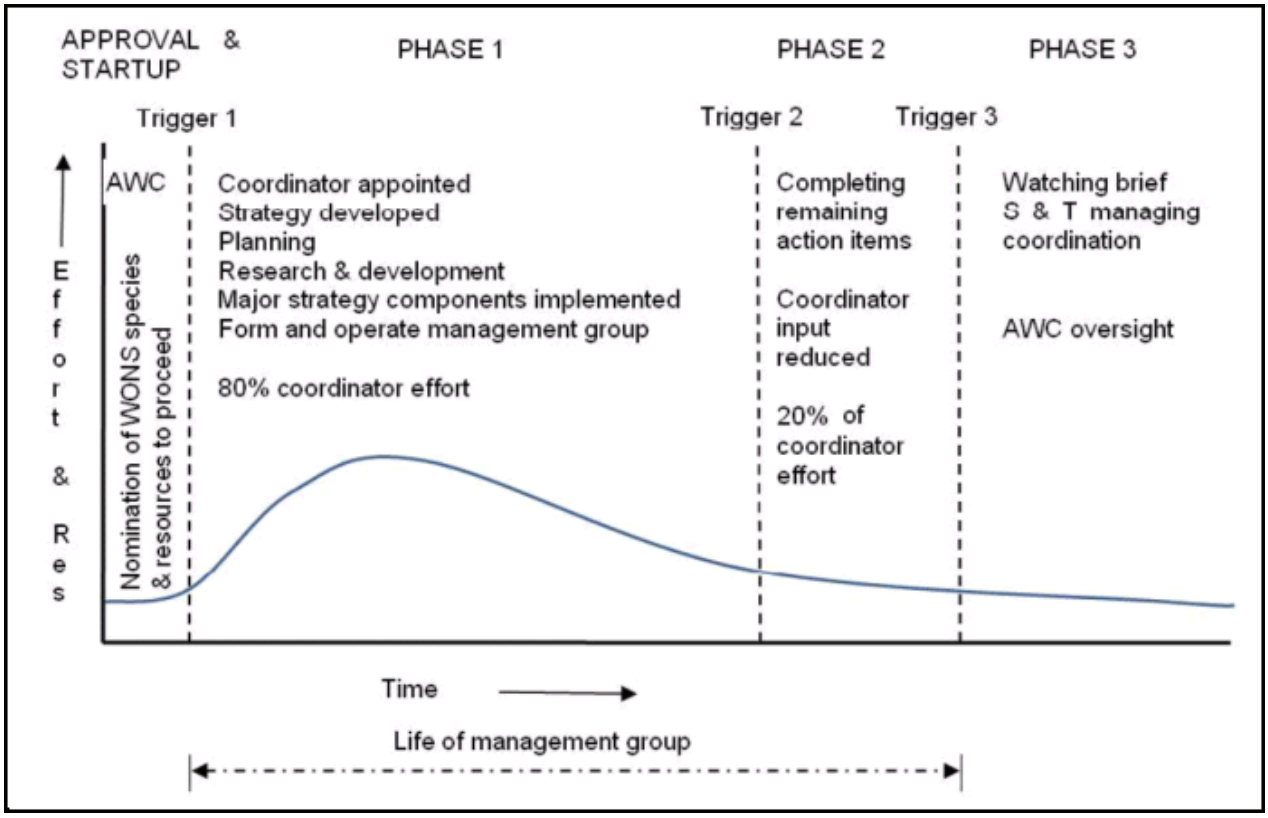


Figure 6. Australian Weed Committee diagrammatic representation of coordinator effort and resource use when implementing a Weeds of National Significance strategy

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

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

7.3 Other information sources

Silverleaf nightshade was inducted as a Weed of National Significance (WoNS) in April, 2012. Information and resources, as they become available, will be posted at www.weeds.org.au/WoNS/silverleafnightshade

7.4 Definitions and Glossary

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

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

Coordinated control - A strategic weed management program that considers all infestations, and involves the application of integrated weed control procedures towards a specific outcome of eradication or containment.

Core infestation – Weed infestation which is large and currently not practically eradicable for a defined scale.

Eradication -The elimination of every single growing individual and viable propagule of a species from an area.

Outliers – Infestations separate from core infestations, and may be eradicable.

Priority outliers – Geographically or otherwise strategically significant outliers that can be eradicated or managed to protect important clean assets.

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

Partner – Person(s) or organisation actively supporting weed management.

Stakeholder – Person, group or organisation with an interest in, or capability to, reduce the impact of weeds.

AG: Australian Government

AWC: Australian Weeds Committee

CfoC: Caring for Our Country

IGAB: Inter-governmental Agreement on Biosecurity.

GRDC: Grains Research and Development Corporation

LGA: Local Government Authority

MLA: Meat and Livestock Australia

NRM/CMA: Natural Resource Management/Catchment Management Authority

RIRFs: Rural Industry Research Funds

S&T: States and Territories

SLN: Silverleaf nightshade

SLNNMC: Silverleaf nightshade national management committee.

WoNS: Weeds of national significance.

7.5 References

Amor, R.L. (1977). Some aspects of the ecology and control of silver-leaf nightshade in Texas, California, Chile and Argentina. Unpublished report (KTRI UR 1977/6), Keith Turnbull Research Institute, Vermin and Noxious Weeds Destruction Board, Frankston, Victoria, Australia, 13 pp.

Anon. (1980). Report on silverleaf nightshade research. Department of Crown Lands and Survey, Victoria.

Beale, R., Fairbrother, J., Inglis, A., and Trebeck, D. (2008). One Biosecurity: a Working Partnership. Commonwealth of Australia. Canberra.

Bekkouche, K. Markouk, M. Larhsini, M. Jana, M, and Lazrek, H. B. (2000). Molluscicidal properties of glycoalkaloid extracts from Moroccan Solanum species. *Phytotherapy Research*. 14, 366-367.

Bouhache, M., Boulet, C. and El Karakhi, F. (1993). Evolution des hydrates de carbone non structuraux chez la morelle jaune (*Solanum elaeagnifolium* Cav.) *Weed Research* 33, 291-8.

Boyd, J.W. and Murray, D.S. (1982). Growth and development of silverleaf nightshade (*Solanum elaeagnifolium*). *Weed Science* 30, 238-43.

Boyd, J.W., Murray, D.S. and Tyrl, R.J. (1984). Silverleaf nightshade, *Solanum elaeagnifolium*, origin, distribution and relation to man. *Economic Botany* 38, 210-17.

Carretero, J.L. (1989). The alien weed flora of the Valencian community of Spain. *Proceedings of the 4th EWRS Symposium on Weed Problems in Mediterranean Climates* 2, 113-24.

Carter, R.J. (1992). Coordinated control of silverleaf nightshade reduces its spread rate. *Proceedings of the 1st International Weed Control Congress*, Melbourne, Australia, Volume 2, pp. 109-12.

Chiale, C.A., Cabrera, J.L., and Juliani, H.R. (1991). Kaempferol 3-(6'-cis-cinnamoylglucoside) from *Solanum elaeagnifolium*. *Phytochemistry* 30, 1042-43.

Connell, S.W. and Panetta, F.D. (1993). Biology and ecology of weeds*. In* 'Management of Agricultural Weeds in Western Australia'. Bulletin 4243, Department of Agriculture Western Australia, Grains Research and Development Corporation, and Agricultural Protection Board of Western Australia, p. 32.

Cooley, A.W. and Smith, D.T. (1972). Seed aspects of two perennials – woollyleaf bursage and silverleaf nightshade. *Proceedings of the Southern Weed Science Society* 25, 443.

Cuda, J. P.; Parker, P. E.; Coon, B. R.; Vasquez, F. E., and Harrison, J. M. (2002). Evaluation of exotic Solanum spp. (Solanales: Solanaceae) in Florida as host plants for the leaf beetles *Leptinotarsa defecta* and *L. texana* (Coleoptera: Chrysomelidae). *Florida Entomologist*. 85, 599-610

Cuthbertson, E.G. (1976). Morphology of the underground parts of silverleaf nightshade. *Proceedings of the Australian Weeds Conference*, Melbourne, pp. 3.7-3.8.

Cuthbertson, E.G. and Leys, A.R. (1976). Silverleaf nightshade – a potential threat to agriculture. *Agricultural Gazette of New South Wales* 87, 11-3.

Davis, C.H., Smith, T.J. and Hawkins, R.S. (1945). Eradication of white horse nettle in southern Arizona. Agricultural Experimental Station, University of Arizona, Tucson. Bulletin 195.

Dellow, J.J. (1993). Distribution of silverleaf nightshade (*Solanum elaeagnifolium*) in the sheep/wheat belt of New South Wales. *Proceedings of the 10th Australian and 14th Asia-Pacific Weeds Conference*, Brisbane, Queensland, ed. J.T. Swarbrick, Volume 2, p. 131.

Dittmer, H.J. (1959). A study of the root systems of certain sand dune plants in New Mexico. *Ecology* 40, 265-73.

DPI (2010). Invasive Plants and Animals Policy Framework, State Government of Victoria, Melbourne.

Eleftherohorinos, I.G., Bell, C.E. and Kotoula-Syka, E. (1993). Silverleaf nightshade (*Solanum elaeagnifolium*) control with foliar herbicides. *Weed Technology* 7, 808-11.

Ferrell, J. A., Mullahey, J. J., Langeland, K. A., and Kline, W. N. (2006). Control of tropical soda apple (*Solanum viarum*) with aminopyralid. *Weed Technology* 20, 453-457.

Goeden, R.D. (1971). Insect ecology of silver-leaf nightshade. *Weed Science* 19, 45-51.

Green, J.D., Murray, D.S. and Stone, J.F. (1988). Soil water relations of silverleaf nightshade (*Solanum elaeagnifolium*) with cotton (*Gossypium hirsutum*). *Weed Science* 36, 740-46.

Hawker V., Preston C. and Baker J. (2006). Genetic variation within and among silverleaf nightshade (*Solanum elaeagnifolium* Cav.) populations in South Australia. *Proceedings of the 15th*

Australian Weeds Conference; Adelaide, South Australia; 176.

Heap, J.W., and Carter R.J. (1999). The biology of Australian weeds. 35. *Solanum elaeagnifolium* Cav*. Plant Prot. Quart*. 14(1). pp.2-12.

Heap, J.W. and Honan, I. (1993). Weed seed excretion by sheep – temporal patterns and germinability. *Proceedings of the 10th Australian and 14th Asia-Pacific Weeds Conference*, Brisbane, Queensland, ed. J.T. Swarbrick, pp. 431-3.

Hennessy, G.F. (1995). Silverleaf nightshade in NSW. Agnote Reg3/53, NSW Agriculture.

Holm, L.G., Pancho, J.V., Herberger, J.P. and Plucknett, D.L. (1991). 'A geographical atlas of world weeds'. (Krieger Publishing Company, Mala-bar, Florida).

Hobbs, R.J. and Humphries, S.E. (1995). An integrated approach to the ecology and management of plant invasions. *Conservation Biology* 9:761–770.

Hoffmann, J.H., Moran, V.C., and Impson, F.A.C. (1998) Promising results from the first biological control programme against a solanaceous weed (*Solanum elaeagnifolium). Agriculture, Ecosystems and Environment*. 70. Pp. 145-150.

Kaul, B. L. and Zutshi, U. (1973). *Solanum elaeagnifolium* Cav., a potential source of solasodine. *Indian Journal of Pharmacy*. 35, 94-96

Kloot, P.M. (1986). Checklist of the introduced species naturalized in South Australia. South Australian Department of Agriculture Technical Paper No. 14 (Agdex 305/06), p. 88.

Kwong, R.M., Sagliocco, J.L., Weiss, J., Hunt, T., and Tereso Morfe, T. (2008). Feasibility of biological control of silverleaf nightshade in Australia. *Proceedings of the 16th Australian Weeds Conference*, Cairns, pp. 256-258.

Lemerle, D. (1983). Silverleaf nightshade. Agfact P7.6.10 (Agdex 647), Department of Agriculture NSW.

Lemerle, D. and Leys, A.R. (1991). Control of silverleaf nightshade increases the grain yield of wheat. *Australian Journal of Experimental Agriculture* 31, 233-6.

Leys, A.R. and Cuthbertson, E.G. (1977). *Solanum elaeagnifolium* Cav. (silverleaf nightshade) in Australia. *Proceedings of the Southern Weed Science Society* 30, 137-41.

Markouk, M.; Bekkouche, K.; Larhsini, M.; Bousaid, M.; Lazrek, H. B., and Jana, M. (2000). evaluation of some Moroccan medicinal plant extracts for larvicidal activity. *Journal of*

Ethnopharmacology. 73, 293-297.

McKenzie, D.N. (1976a). Silverleaf nightshade – another perennial problem. *Proceedings of the Australian Weeds Conference*, Melbourne, pp. 3.9-3.10.

McKenzie, D.N. (1976b). Silverleaf nightshade – community attitudes on containment. *Proceedings of the Australian Weeds Conference*, Melbourne, pp. 7.14-7.16.

McKenzie, D.N. (1980). Report on silver-leaf nightshade research. Pamphlet No. 79, Department of Crown Lands and Survey, Victoria, Australia.

McKenzie, D.N. and Douglas, G.W. (1974). Report on white horsenettle (or silver-leaf nightshade) *Solanum elaeagnifolium* Cav. Pamphlet No. 50, Vermin and Noxious Weeds Destruction Board, Department of Crown Lands and Survey, Victoria, Australia.

Molnar, V.M. (1982). Final report on silver-leaf nightshade (*Solanum elaeagnifolium* Cav.) field trials in the Victorian Mallee 1974–1980. Unpublished report (KTRI UR 1982/1), Keith Turnbull Research Institute, Vermin and Noxious Weeds Destruction Board, Frankston, Victoria, Australia, 70 pp.

Molnar, V.M. and McKenzie, D.N. (1976). Progress report on silverleaf nightshade. Pamphlet No. 61, Vermin and Noxious Weeds Destruction Board, Keith Turnbull Research Institute, Victoria, Australia.

Monaghan, N. and Brownlee, H. (1979). Regeneration of *Solanum karsensis* and *S. elaeagnifolium*. *Proceedings of the 7th Asia-Pacific Weed Science Society Conference*, pp. 321-3.

Monaghan, N.M. and Brownlee, H. (1981). Control of *Solanum karsensis* in grain sorghum. Weed Research 21, 43-6.

Moore, R.M., Parsons, W.T., Strang, J. and Tideman, A.F. (1975). Silver-leaf nightshade (*Solanum elaeagnifolium* Cav.). *Australian Weeds Research Newsletter* 22, 5-13.

Olckers, T. (1997). *Solanum elaeagnifolium* – biological and integrated control of this weed in South Africa. *Plant Protection News (Plantbeskermingsnuus)* (South Africa) 49, 2-4.

Olckers, T., Moran, V.C. and Hoffmann, J.H. (1996). Improved prospects for biological control of three *Solanum* weeds in South Africa. *Proceedings of the 9th International Symposium on Biological Control*, pp. 307-12.

Panetta, F.D. and Mitchell, N.D. (1991). Bioclimate prediction of the potential distributions of some weed species prohibited entry to New Zealand. *New Zealand Journal of Agricultural Research* 34, 341-50.

Parsons, W.T. (1973). 'Noxious weeds of Victoria'. (Inkata Press, Melbourne).

Parsons, W.T and Cuthbertson, E.G. (1992). 'Noxious weeds of Australia'. (Inkata Press, Melbourne).

Richardson, R.G. and McKenzie, D.N. (1981). Regeneration of, and toxicity of 2,4-D to, root fragments of silver-leaf nightshade (*Solanum elaeagnifolium* Cav.). *Journal of the Australian Institute of Agricultural Science* 47, 48-50.

Rutherford, P.A. (1978). Effect of time of immersion in running and still water on the germination of silverleaf nightshade. *Proceedings of the 1st Conference of CAWSS*, Melbourne, pp. 372-7.

Sathiyamoorthy, P.; Lugasi-Evgi, H.; Schlesinger, P.; Kedar, I.; Gopas, J.; Pollack, Y., and Golan-Goldhirsh, A. (1999). Screening for cytotoxic and antimalarial activities in desert plants of the Negev and Bedouin market plant products. *Pharmaceutical Biology*. 37, 188-195

Smith, K.R. (1975). A new system of surveying and its use on silverleaf nightshade. *Journal of Agriculture*, South Australia 78, 35-9.

Stanton R.A., Heap, J.W., Carter, R.J. and Wu, H. (2009). *Solanum elaeagnifolium* Cav. (revised). *In* "The biology of Australian weeds" ed. F.D. Panetta. pp. 274-293. (R.G. and F.J. Richardson, Melbourne, Australia).

Tideman, A.F. (1960a). Tomato weed. *Journal of the South Australian Department of Agriculture* 63, 329-31.

Tiemann, K. J.; Rascon, A. E.; Gamez, G.; Parsons, J. G.; Baig, T.; Cano-Aguilera, I., and Gardea-Torresdey, J. L. (2002). Heavy metal binding by inactivated tissues of *Solanum elaeagnifolium*: chemical and subsequent XAS studies. *Microchemical Journal*. 71,133-141.

Thorp. J. (2012). "Additional List of Weeds of National Significance – April 2012" www.weeds.org.au/WoNS.

Trione, S.O. and Cony, M.A. (1990). Thermoperiodism and other physiological traits of *Solanum elaeagnifolium* seeds in relation to germination. *Seed Science and Technology* 18, 525-39.

Vigna, M.R., Fernandez, O.A. and Brevedan, R.E. (1983). Germination of *Solanum elaeagnifolium* Cav. *Studia-Oecologica* 2, 167-82.

Wapshere, A.J. (1988). Prospects for biological control of silverleaf nightshade, *Solanum elaeagnifolium*, in Australia. *Australian Journal of Agricultural Research* 39, 187-97.

Wassermann, V.D., Zimmermann, H.G. and Neser, S. (1988). The weed silverleaf bitter apple ('Satanbos') (*Solanum elaeagnifolium* Cav.). Technical communication No. 214. Plant Protection Research Institute, Pretoria, Republic of South Africa, Department of Agriculture and Water Supply.

Wilson, P.D., Downey, P.O., Gallagher, R.V., O'Donnell, J., Leishman, M.R. and Hughes, L. (2011) Modelling climate suitability for exotic plants in Australia under future climate. Final Report on the potential impact of climate change on the distribution of national priority weeds in Australia. Macquarie University and New South Wales Office of Environment and Heritage, Sydney, Australia.