Weeds of National Significance

Lantana



Best Practice Manual and Decision Support Tool

NSW GOVERNMENT

Australian Government

Queensland Government

Lantana

Best Practice Manual and Decision Support Tool

Weeds of National Significance

August 2009

This manual has been produced through the cooperative efforts of the Australian Government and the Queensland and New South Wales state governments

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Foreword

In director Ray Lawrence's award-winning psychological thriller *Lantana*, the title was used as a metaphor to describe the intertwined brambles of love and deceit—an example of something that is superficially beautiful but conceals a hidden menace. Although this Weed of National Significance has achieved pop culture status as a result of the movie, it is probably true to say that the majority of moviegoers missed the significance of the title and were unaware of the serious threat lantana poses.

Lantana is considered to be one of the ten worst weeds in the world. It has invaded more than four million hectares of eastern Australia and is entrenched in our primary production areas, World Heritage Areas, our beach sides and even our backyards. It has become so much a part of the Australian landscape that, to some, the distinctive smell of its crushed leaves is synonymous with nature and 'the bush'.

The Lantana Weeds of National Significance Program—coincidentally launched in 2001, the same year the movie was released—has been striving to change public perception about this weed and increase our knowledge of how best to tackle it. This manual and Decision Support Tool form another important weapon in the arsenal of management and planning options that are being amassed to ensure we protect our most valuable economic, social and environmental assets into the future.

Building on the first Lantana Control Manual, produced in 2004, this resource provides a comprehensive source of information on lantana behaviour and biology, as well as important and practical management information. The manual provides vital guidance on the integration of control options and strips away potential confusion by providing a user-friendly Decision Support Tool to help shape management practices.

A concerted effort is required to achieve effective and strategic control of this major weed. This manual demonstrates that through planning, appropriate investment and ongoing diligence, the war on controlling lantana can be won.

Kym Johnson

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How to use this manual

What were the sources for the information provided in this manual?

The information in this manual was drawn from a series of adaptive management trials at eleven sites throughout the Queensland and New South Wales distribution of lantana. The experimental sites included a range of conservation and primary production areas with differing rainfall and climatic conditions to gain a broad picture of the response of lantana to management actions. Other information that could not be collected directly was compiled from a survey of field practices, reviews by technical experts and previously published information.

How do I use this resource?

The *Lantana Best Practice Manual* provides a comprehensive guide to the biology and ecology of the weed, the range of management options and how to integrate them, as well as information on how to plan and monitor your control activities.

Along with the Decision Support Tool, a computer-based tool to help determine the most appropriate sequence of initial and follow-up control for your particular management situation, this resource should enable the implementation of an efficient and cost-effective management program on your property.

The Lantana profile

This section provides information on the weed itself, its physical characteristics, distribution, biology and ecology.

The main body of the document is divided into four sections.

Section 1: Designing a control program—issues to consider

Use this section to identify factors that will influence your decision-making process.

This section describes the key factors that will have an impact on the feasibility of control and your decision-making process. Issues to consider include economic, climatic, varietal and land use factors.

Section 2: The lantana seven-step plan

Refer to this section for guidance on the integration of lantana into your property pest management plan.

The importance of planning, realistic goal setting and staged and integrated control are highlighted in this section. Monitoring and review techniques are included to enable the land manager to assess their achievements.

Section 3: Control methods

Refer to this section for detailed information on the available management techniques.

This section describes each control method in detail and provides guidance to determine when it is appropriate to use them. A variety of management options should be integrated into a control program to achieve the most successful management outcomes.

Section 4: Using the Decision Support Tool

Section 4 defines the key variables used in the Decision Support Tool.

The superscript numbers in the text refer to the relevant reference sources, listed in the References section on page 116.

Sections

The lantana profile

Lantana—A Weed of National Significance

Lantana (*Lantana camara* L.) is one of Australia's most damaging invasive weeds. It is an aggressive invader that has naturalised in eastern Australia under a wide range of climatic conditions[67] and is recognised as a major weed of pastures, plantations and native forests.[5,15,42] Since its introduction to Australia as an ornamental plant in the early 1840s,[66] lantana has spread to infest more than four million hectares of eastern Australia, from southern New South Wales to northern Queensland, and has invaded areas of the Torres Strait Islands, Northern Territory and Western Australia.[14] In recognition of its impacts on primary industries, conservation and biodiversity, and the extent of its distribution in Australia, lantana has been named a Weed of National Significance.[70]

Lantana originates from tropical and subtropical America and is now classed as a serious weed in more than 60 countries.[32] It is considered a major problem to agriculture where it occurs in East Africa, Fiji, Hawaii, India, the Philippines, South Africa and Zambia [32] and there are currently more than 650 hybrid varieties identified.[33] Consequently, lantana is considered to be one of the *ten worst weeds worldwide*.[59]

Without a concerted effort on behalf of land managers across the plant's distribution, lantana will continue to infest new areas of natural ecosystems and productive land, and increase in density in areas that have already been invaded. Preventing any further spread in Australia is an extremely high priority for the sake of our natural biodiversity and grazing industries.

Lantana excluding pasture—Tallawalah, Queensland.

Lantana invades disturbed rainforest—Springbrook National Park, Queensland.

Lantana in woodland pasture—Glen Ruth, Queensland.

The real cost of lantana

The economic, environmental and social impacts of lantana range widely across land use situations, affecting land managers, local, state and federal governments, community groups, and industry.

Economic impacts

Australian grazing sector

Productivity costs

In agricultural situations, lantana invades pastures and grazing lands, fence lines, riparian areas, cultivated land and orchards.

It has been estimated that lantana infestations cost the Australian grazing sector more than $104 million per year (2005–06 values) in lost productivity, with landholders incurring an average cost of $42.78/ha per year where lantana is present.[3]

This consists of:

- $6.40/ha in stock poisoning
- $5.50/ha in increased mustering costs
- $19.55/ha in reduced carrying capacity
- $11.33/ha in increased maintenance expenditure.

However, there is considerable variation in these figures depending on the density of infestation and level of management activity. Another study estimated that increased mustering costs alone can be as much as $65 per hectare in densely infested areas for the beef industry and $55 per hectare for the dairy industry.[55]

Small dozers used to clear lantana from between rows to allow access in hoop pine plantations—Yarraman, Queensland.

Toxic effects of lantana to livestock—Tallawalah, Queensland.

Increased control costs

It is estimated that land managers in the grazing industry spend more than $17 million annually on lantana control.[3]

Where control initiatives are undertaken, landholders spend on average:

- $44.00/ha in the treatment area in light infestations (scattered lantana)
- $62.60/ha in the treatment area in medium infestations (lantana starts to impede ability to walk on a property)
- $75.10/ha in the treatment area in heavy infestations (lantana prohibits any movement on a property).[3]

Australian silvicultural industry

In commercial forestry, lantana raises production costs, increases the risk of damage by fire and impedes access. In commercial hoop pine plantations of coastal south-east Queensland, where lantana competes with seedlings for light and reduces access during harvest time, it is estimated that lantana's presence accounts for 30 per cent of the establishment costs and up to 50 per cent of the harvesting costs.[79]

Economic costs to environmental systems

Environmental systems play an important role in supporting ecosystem function, biodiversity and providing amenity and recreational value. However, it is difficult to put an economic value on the protection of these assets.

Lantana and ecotourism

The economic impact lantana poses to the Queensland and New South Wales ecotourism industries has not yet been assessed. However, with a growing number of important conservation areas including World Heritage Areas under threat from lantana, this cost is likely to be significant.

Active growth—Springbrook National Park, Queensland.

The best assessment we have to date of the 'value' of these assets comes from a 2003 Queensland economic survey which demonstrated that Queenslanders would be willing to pay $72.5 million per annum to protect high conservation areas from lantana infestation.[2]

Biodiversity impacts

Lantana has a serious impact on native biodiversity and recent research shows that it threatens more than 1400 native species and 100 threatened ecosystems. This includes 279 plants and 93 animals listed under state and/or national threatened species legislation.[73]

In natural ecosystems, lantana invades forest edges, coastal zones and riparian areas, penetrates disturbed rainforest and invades open eucalypt woodland. In dense thickets, lantana excludes native species through smothering[6,62] and allelopathic effects[27,28] (i.e. toxicity to other plants). It dominates understoreys, prolongs succession[26] and reduces biodiversity.[6,15,25,40,63,64,67] Lantana thickets may also increase the intensity of wildfires,[67] which can have disastrous effects on fire-intolerant native flora and fauna. Conversely, in some environments lantana retards the invasion of fire, suppressing the germination of native species that require the catalyst of fire.

A national 'Plan to Protect Environmental Assets from Lantana' has been developed to focus management attention toward species at greatest risk from lantana invasion. Further information, including a list of the species affected by lantana, can be found at: www.environment.nsw.gov.au/lantanaplan

The endangered mahogany glider (*Petaurus gracilis*) is just one of several Wet Tropic native species at risk from lantana invasion. In this environment lantana blocks fire, a major catalyst in the germination process of the animal's primary food tree *Albizia procera*, thus reducing the availability of food trees for the endangered gliders.

Mahogany Glider—North Queensland.

Social impacts

The social impacts of widespread weeds such as lantana can have a significant effect on general wellbeing and should be an important consideration in the decision-making process associated with priority management areas.

Important social impacts of lantana include:

- increases in individual and social stresses associated with economic loss
- impacts on valuable cultural heritage areas
- reduced recreational opportunities such as hiking, bush walking and camping
- reduced aesthetic appeal of many natural areas, affecting eco-tourism opportunities.

Perceived benefits of lantana—the pros and the cons

As habitat

Lantana thickets can provide a substitute habitat for a range of animals, including bandicoots, whipbirds, quail, wrens, birdwing butterflies and brush turkeys, where it has replaced the natural understorey vegetation.

However, due to the structural and nutritional simplification caused by lantana invasion, these habitats cannot support the range of animals found in most environmental systems. In addition, lantana provides a refuge for feral animals such as cats, pigs, rabbits, foxes and wild dogs, which compound the negative impacts on native plant and animal populations.

Lantana provides substitute habitat.

Natural area restoration projects occurring in heavily infested regions should ensure lantana is controlled gradually and the food and structural habitat provided by lantana is replaced to provide continued support for native species.

As a buffer

In some disturbed rainforest areas, lantana prevents invasion by grass and other weeds, and can form a useful temporary buffer along forest edges for bush regeneration projects.

Lantana can provide a buffer along forest edges.

However, this management technique should be treated with caution as there is the potential for seed spread into breaks and disturbed sections of the rainforest, further affecting the integrity of the system. In areas of more open vegetation, such as sclerophyll forests, this technique should not be employed as lantana will readily invade open-canopy systems.

Species benefiting from lantana: 142
Species at risk from lantana: 1480

In farm management

In some agricultural contexts, infestations of lantana are thought to prevent soil compaction, and are valued as a source of organic matter for pasture renovation or improvement. The weed is also considered to be useful in steep areas and stream banks for stabilising soil and preventing erosion. In some cases, it suppresses weeds perceived to be worse.

Once again, these management techniques should be considered carefully. There must be the capacity, on behalf of the land manager, to eventually control lantana infestations for there to be any advantage in reduced soil compaction and increases in organic matter. In addition, lantana may reduce deep erosion; however, as the surface soil below lantana infestations is relatively devoid of ground cover, it is prone to desiccation and loss of humus layers due to surface run-off.

As a garden ornamental

The sale and distribution of all varieties of *Lantana camara*, including horticultural varieties, has been banned in all states and territories of Australia. *Lantana montevidensis* (creeping lantana) is also restricted in selected areas (For further information on legislative restrictions in your state, refer to Appendix 5). However, lantana is still valued for its colour and low maintenance requirements and remains a common fixture in many public and private gardens.

Garden plantings of lantana pose a risk in two main ways: through the spread of seed by birds and mammals; and through the introduction of 'enhanced' genetic material into wild populations. While many of the ornamental varieties were marketed as sterile, research indicates that a portion of the pollen produced is still viable and when cross-fertilisation occurs between 'sterile' and weedy varieties, viable seed and fertile offspring can be produced.[48,60] This has the potential to increase drought and frost tolerances in weedy lantana populations and to reduce the effectiveness of biocontrol agents.

The sale of *Lantana camara* has been banned in all states and territories in Australia.

Lantana as a garden ornamental—Adelaide, South Australia.

Description

Lantana camara—a species complex

The weed known as *Lantana camara* in Australia is a highly variable hybrid plant probably originating from two or more lantana species from tropical America. The Latin name *Lantana camara* refers in the strict sense to one Caribbean species, but in Australia, as in other countries, the name has been used mostly as a convenient reference for the highly variable weedy species complex. At least 29 varieties (indicated by flower colour, structure of leaf hairs, thorniness, and length of bracts) are reportedly present in Australia, and have been divided into five main types identified by flower colour: pink, white, pink-edged red, red and orange (see Figure 2).

Physical description

- Lantana is a heavily branching shrub that grows 2–4 m high as compact clumps or dense thickets. It is able to climb to 15 m with the support of other vegetation.
- Lantana has arching stems that are square in cross-section, with pithy centres and short, backwardly hooked prickles or spines. Aged stems can be up to 15 cm in diameter.
- The leaves are 2–10 cm long with toothed edges, bright green on the upper surface and paler green, hairy and strongly veined on the underside. They grow opposite one another along the stems, and their size and shape depends on the type of lantana and the availability of light and moisture.
- The plant has a shallow root system made up of a short taproot with lateral roots branching out to form a mat.
- The inflorescences (clusters of 20–40 individual flowers) are about 2.5 cm in diameter. Tightly packed, angular flower buds open from the outside towards the centre of the inflorescence as they mature.
- Single-seeded hard green fruit, of about 5–7 mm, grow in clusters and ripen to shiny black or purple fleshy berries.
- Crushing the stems and leaves produces a strong characteristic smell.

Leaf variation in the five colour types

Variations in leaf colour, size and texture can generally be associated with the different lantana colour types:

Pink lantana—large, pale green leaves with a velvety texture

White lantana—small, tough leaves, less velvety than those of pink lantana

Pink-edged red lantana—small, tough leaves, darker than those of pink lantana

Red lantana—large, dark green leaves with a velvety texture

Orange lantana—small, tough leaves that are rough and hairy.

Leaf sizes and shapes can vary.

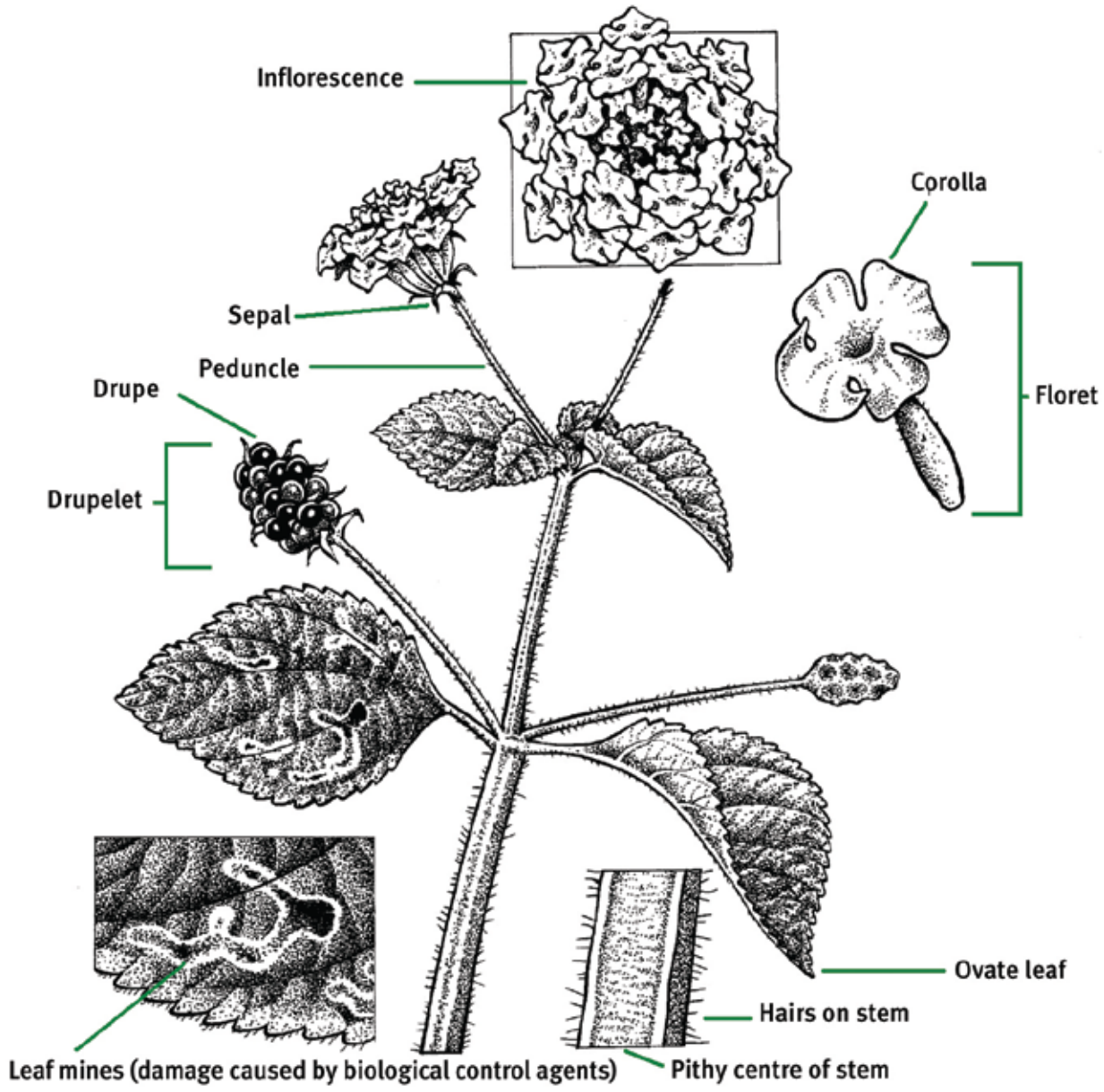


Figure 1: Anatomical drawing of lantana

Colour types of lantana

Identification of lantana types by flower colour can be difficult, as the colours of the inner buds as well as the inner and outer flowers must be considered. The five main colour types are known as pink, white, pink-edged red, red and orange.

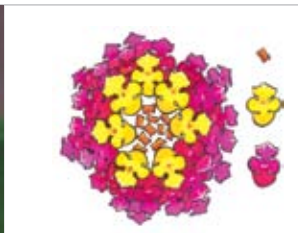
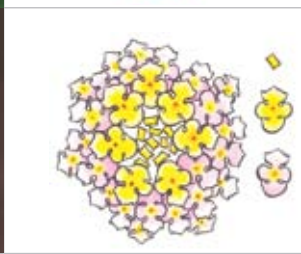
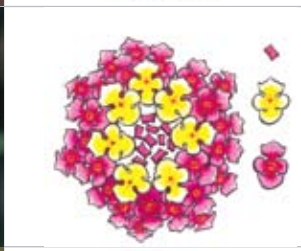
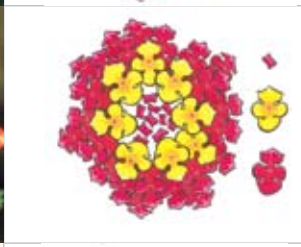
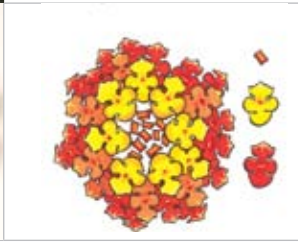
		**Pink *Lantana camara*** **Bud:** pink/parchment **Middle ring:** yellow throat, pale yellow petals **Outer ring:** orange throat, pale or dark pink petals
		**White *Lantana camara*** **Bud:** cream **Middle ring:** yellow throat, pale yellow petals **Outer ring:** orange or yellow throat, lilac petals
		**Pink-edged Red *Lantana camara*** **Bud:** pink to dull red **Middle ring:** orange throat, pale yellow to orange petals **Outer ring:** orange throat, with two-toned pink to red colour petals (inner darker than outer)
		**Red *Lantana camara*** **Bud:** blood red **Middle ring:** yellow throat with yellow petals **Outer ring:** red throat with red petals
		**Orange *Lantana camara*** **Bud:** orange **Middle ring:** yellow to orange throat, yellow petals **Outer ring:** orange throat, orange petals

Figure 2: Identifying lantana types by colour

Lantana montevidensis (creeping lantana)

Purple or lilac flowers with white or yellow centres generally indicate another weedy species, *Lantana montevidensis*, or creeping lantana. *L. montevidensis* is a scrambling low woody shrub that is invasive in coastal and subcoastal areas. It features:

- stems that are square in cross-section, and without prickles
- leaves up to three centimetres long
- short, profusely flowering branches that form mats.

This manual deals only with *L. camara*. Information about *L. montevidensis* is provided here to help identify the two species.

Ornamental lantana

Both *L. camara* and *L. montevidensis* have been developed as ornamentals in Australia. They are available in a similar range of flower colours (lilac, pink, red, orange, yellow, and white—some of which are illustrated below) to the weedy varieties, making it difficult to distinguish between them; however, the ornamental varieties of both species are generally smaller, more compact plants with smaller leaves.

The ornamental yellow *L. camara* hybrid and the lilac and white ornamental *L. montevidensis* varieties are commonly seen in public places and gardens.

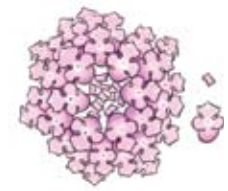
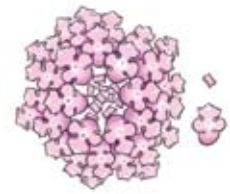
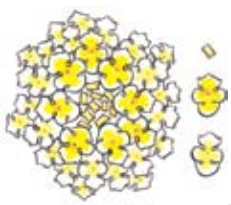
		**Lilac *Lantana montevidensis*** (creeping lantana) **Bud:** lilac **Middle and outer ring:** white throat, lilac to mauve petals
		**Ornamental yellow *Lantana* spp.** **Bud:** pink/parchment **Middle and outer ring:** ochre yellow throat and petals
		**Ornamental lilac *Lantana montevidensis*** **Bud:** lilac **Middle and outer ring:** white to yellow throat, lilac to mauve petals
		**Ornamental white *Lantana montevidensis*** **Bud:** white to cream **Middle ring:** yellow throat, white petals **Outer ring:** pale yellow throat, white petals

Figure 3: Lantana montevidensis *(creeping lantana) and ornamental lantana*

Brisbane, 1889

Distribution: current and potential infestations

Early history

Lantana has been a weed in Australia for at least 160 years. It was first recorded in 1841 at the Adelaide Botanic Gardens, and, in 1889, dense stands were mapped close to the mouth of the Brisbane River. By 1897, it was described in Brisbane as a 'most troublesome weed' that could form 'impenetrable thickets on the banks of streams, deserted farms and the edges of scrubs'.[8]

Current distribution

Lantana is widely distributed east of the Great Dividing Range, covering more than four million hectares from Eden in New South Wales, along the length of coastal New South Wales and Queensland, to the Torres Strait Islands, including some areas in central western Queensland. Isolated infestations have been reported in the Northern Territory (in and around Darwin, and on the Gove Peninsula) and in Western Australia (around Albany, Perth and Geraldton), in Victoria near Orbost and South Australia near Adelaide (the latter two have been removed as of 2009). See Figure 4.

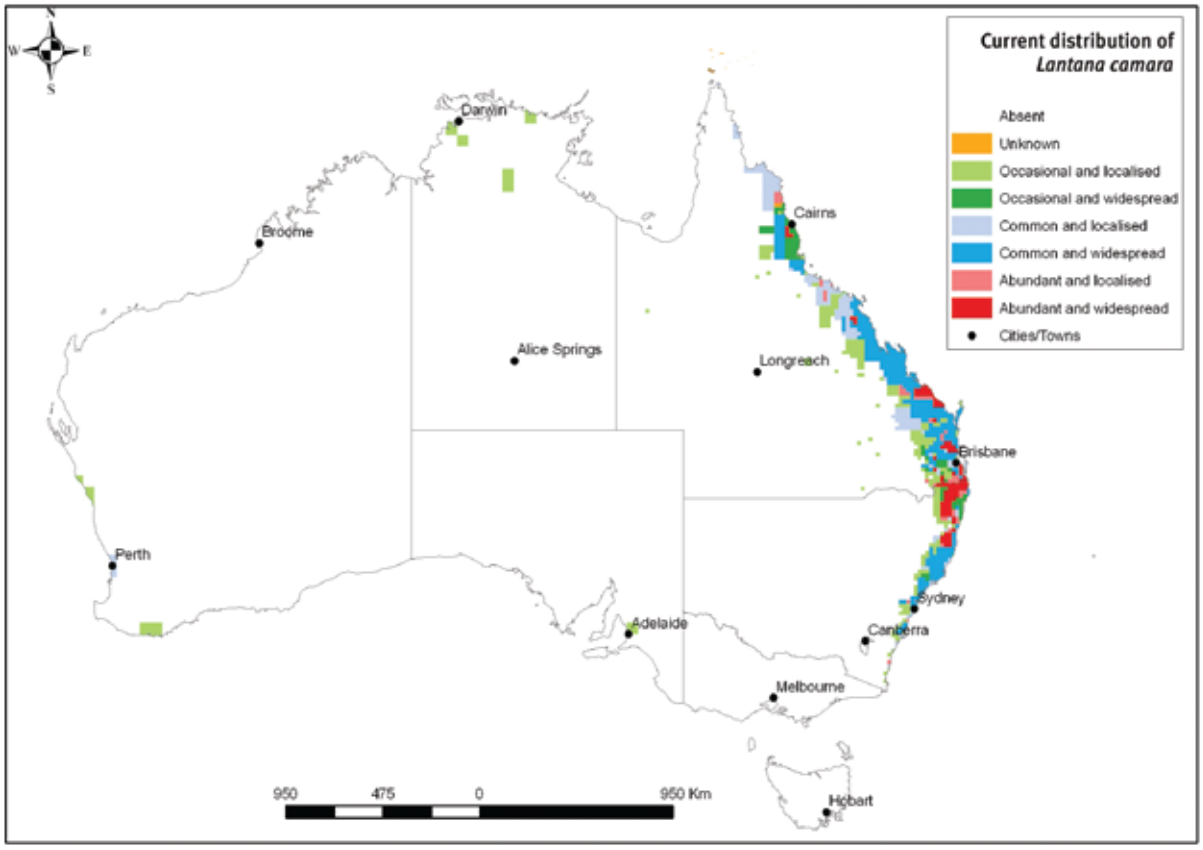


Figure 4: Current distribution of Lantana camara *(2009)*

Potential distribution

The ecological limitations to the distribution of lantana have yet to be clearly defined due to the complex mixture of hybrid varieties that make up the *Lantana camara* species complex. It was believed that lantana had reached its potential range in Australia,[4] and was progressively infilling this area.[5] However, more recent climatic modelling indicates lantana has the potential to invade suitable environments across nearly 35 million hectares of the Australian continent (see Figure 5). That lantana is not yet present in these areas does not mean it is unsuited to them; it has been described as a 'sleeper weed', awaiting conditions favourable to spread.

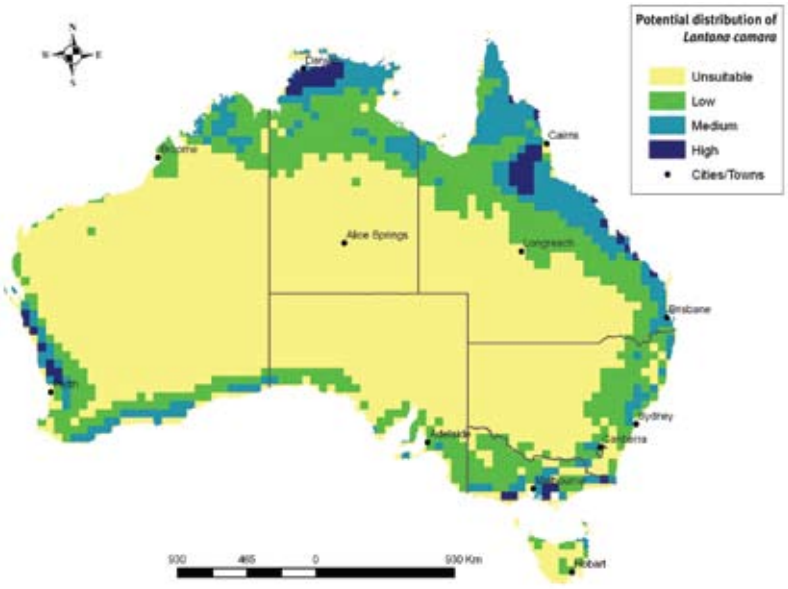


Figure 5: CLIMATE model showing the potential distribution of Lantana camara *in Australia (courtesy of DEEDI)*

Lantana is now present at the headwaters of major west-flowing catchments of the Murray–Darling Basin, and it may be able to spread further west along riparian corridors given favourable climatic conditions, and as a result of inappropriate land management practices. Infestations that were recently discovered in central western Queensland on creeks associated with the Alice and Belyando River systems near the towns of Jericho and Alpha (west of Emerald), demonstrate the weed's capacity to spread.

The impacts of climate change are likely to exacerbate the problem in future, enabling lantana to invade further south and into high altitude areas.[43]

Ornamental lantana increases the risks

Although the sale and distribution of lantana has been banned in all states and territories, ornamental lantana is still present in gardens and landscaping in many areas. Some commercial varieties previously thought to be sterile can, in fact, produce viable seed or hybridise with wild varieties, increasing genetic variation in the species complex.[48,60] This continual variation may enhance the ability of lantana to adapt to new environments and makes the race to find a more effective biological control agent even more difficult.

Ornamental lantana—Emerald, Central Queensland (recently removed by airport administration).

Lantana infestation—Albany, Western Australia (site now under active management).

Reproduction and spread

Lantana invasion appears to be strongly correlated with disturbance. In primary production situations it predominately impacts on unimproved pastures or areas where soil is exposed and competition is reduced. In environmental systems lantana invades where there are significant breaks or gaps in forest canopies.[25,28,58,64,65]

Dispersal of seed

Seeds are dispersed in a number of ways:

- Fruit-eating birds are the main agents of dispersal, as they spread seed in their droppings.[15,67]
- Some mammals also eat and disperse lantana seed.
- Studies have shown that germination is more likely if the seed has travelled through the gut of a bird or mammal.[67]

White lantana seeds in emu droppings.

Vegetative spread

- Lantana can spread via a process known as layering, where horizontal stems take root when they are in contact with moist soil.
- Lantana will also reshoot vigorously from the base of vertical stems (and more slowly from the rooted horizontal stems), although it does not sucker from damaged or broken roots.

Pollination

- Insects such as butterflies, moths, bees and thrips pollinate the flower clusters. Self-pollination is not common.
- Approximately half the flowers form clusters of single-seeded berries. A single plant can produce up to 12 000 fruit each year.

Seed viability

- Lantana seed survival of 21.3 per cent has been recorded after 36 months under natural rainfall conditions and 27.2 per cent after 24 months for seeds placed under irrigated conditions.[76]
- Computer modelling of seed survival projections indicate a small percentage of buried seed can survive up to 11 years under natural rainfall and 3 years under irrigation.[76]

Germination

- As bird dispersal of seed is the main vector of lantana spread, the first place lantana is often encountered is along fence lines, under trees and generally where birds perch. Monitoring and control in these areas can prevent spread into clean paddocks.
- Activities that increase light intensity and soil temperature will stimulate germination of lantana seed. These include human disturbances such as clearing, construction and inappropriate burning, and pest animal activity such as pig rooting and rabbit burrowing.
- Seeds need warm temperatures and sufficient moisture to germinate. Germination is reduced by low light conditions.

Regrowth from base of stems.

Longevity

- Lantana is long-lived under favourable conditions. Constantly renewed growth at the base of stems ensures its persistence. Plants tend to die only under extremely stressful conditions, such as extended drought or complete shading through canopy closure.

Habitat

- Lantana grows in a variety of coastal and subcoastal areas, thriving in high rainfall areas of tropical, subtropical and warm temperate climates.
- The upper temperature limit for lantana is unknown; however, shoots are frost sensitive and growth is reduced below 5 °C.[68,80]
- Lantana growth is significantly constrained by water availability and it prefers conditions where soil moisture is available throughout the year. However, it can grow on poor soils and pure sand substrates if there is adequate soil moisture[68,80] and once established will survive long periods of drought.
- It prospers on well-drained rich clays or volcanic soils (the latter derived from basalt), and particularly rich organic soils developed under rainforest canopies.[36]
- Lantana has the ability to produce shoots all-year-round under favourable soil, humidity, air temperature and light conditions.[67]
- In contrast, lantana does not grow well in saline or waterlogged soils, where its root mat tends to rot.[68]

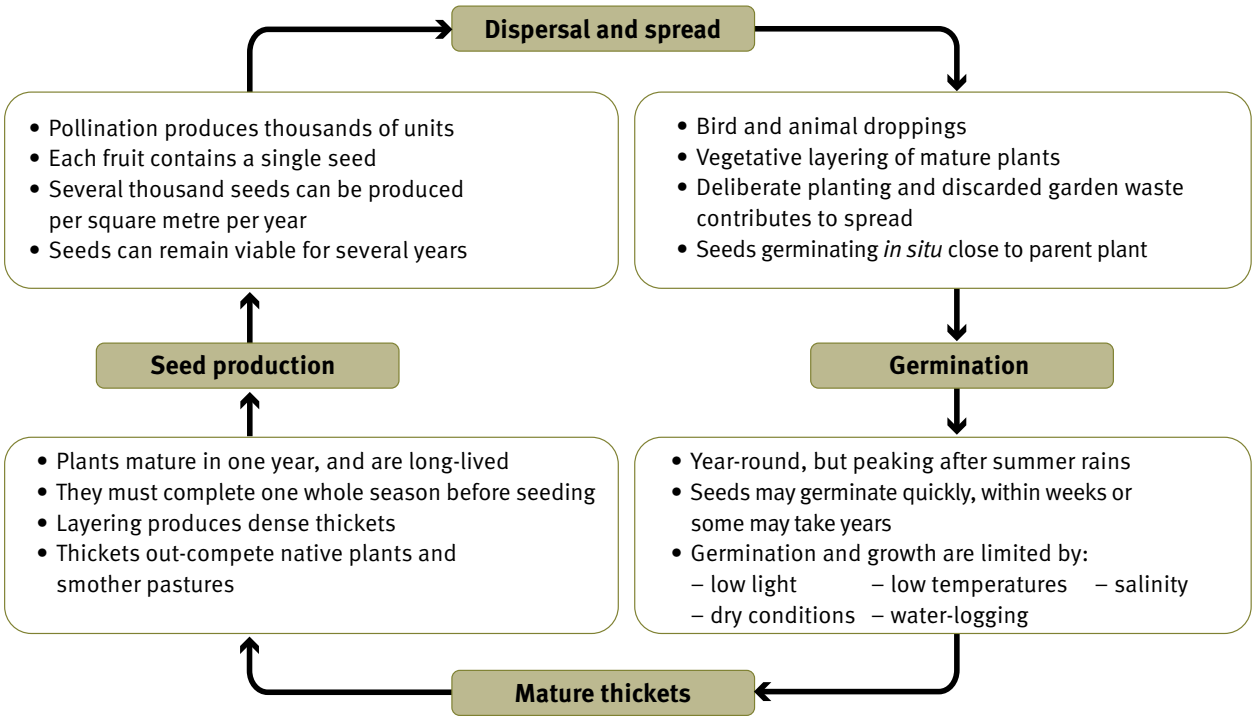


Figure 6: The life cycle of Lantana camara

Section 1

Designing a control program—issues to consider

Lantana control—the golden rules

Lantana management must be tailored to the specific conditions of the site. However, there are a few over-riding guidelines that are common to all situations. These are known as the *golden rules of lantana control*.

1. Property planning—determine your highest priority areas

The first step in any management effort should be to prioritise areas for control where success is most likely or the assets you are protecting are particularly valuable. These could be small infestations that can be removed completely, new infestations that have not yet spread, or areas of high value for production or conservation. A map of the site or property showing areas that have been identified and prioritised for control is a useful planning and monitoring tool (see example in Appendix 1). If multiple sites are being managed for conservation, the Plan to Protect Environmental Assets from Lantana also details a process to determine your highest priority sites.[47]

Early intervention and prevention are important to reduce the need for major efforts in the future. Treatment of large infestations should always begin at the edges and other sparse areas and work towards the denser parts, particularly in areas of high priority. The only clear variant to this is where a particularly important asset, such as an endangered species, requires immediate site-based protection to ensure its survival.[47]

Section 2 provides more detail on property pest management planning.

2. Control in stages, follow up and monitor

Control efforts must be carried out in stages. The initial stage of treatment is often the most difficult, time-consuming and expensive. Follow-up controls tend to be more rewarding, but must be sustained over a number of years to ensure the effort of initial controls is not wasted. Revegetation of the site (either passive or active) to provide competition and build resistance to further weed invasion, and continual monitoring, are other critical stages of a successful control strategy. The integrated management of other weeds should also be undertaken to ensure undesirable plants do not replace the lantana.

In smaller infestations lantana can usually be completely removed from the site. However, follow-up control must still be carried out in combination with revegetation and monitoring.

Larger infestations of lantana usually cannot be completely destroyed with one round of management. In most instances, the removal of the bulk of lantana vegetation (through mechanical treatment or fire) should be considered first to allow more cost-effective follow-up management.

> "Removing Lantana is a waste of time unless cleared areas are revegetated with native trees or pasture immediately. Follow-up regularly until the vegetation is well established."
>
> Landholder, Austinville, Queensland

Section 3 discusses different lantana control techniques available and their advantages and disadvantages.

3. Integrate methods

Integrated control combines two or more methods, targeting vulnerable aspects of the weed's life cycle to achieve a more effective outcome. Lantana can be successfully controlled though a combination of pasture management, regeneration/revegetation, fire, mechanical or hand removal, herbicides and biocontrol. In most situations, integrated control, including follow-up control and revegetation, provides the only chance of a successful and cost-effective outcome.

Section 4 details how best to integrate lantana controls through sequences of primary control and the subsequent follow-up, using the Lantana Decision Support Tool.

Feasibility of control

Effective lantana management can be expensive and time consuming, but there are many reasons why it should be managed. They include improved productivity, conservation of valuable native vegetation and biodiversity, increased property value, or preservation of land for future generations.

The key aim is to achieve the most effective and cost-efficient sequence of management for your situation. An understanding of the variables that should have the greatest influence on your decisions and the costs involved will ensure you can plan effectively and reduce the chance of wasted effort.

The initial choice of control options depends on which methods are appropriate for the land management outcomes desired (e.g. conservation versus production). However, for each outcome there may be several possible control sequences. The choice of sequence that is most suitable to your situation will depend on:

1 the availability of resources over a period of years
2 the desired time frame in which the control should be completed
3 whether complete eradication, or just control/containment is desired.

In many instances, the best returns on investment can be achieved through preventative or early management of lightly infested areas. Targeting light or scattered infestations first is also a good way of building confidence and expertise before tackling denser areas.

The following matrix provides a basic guide for determining priorities for control.

Table 1: Control priorities

		Threat/impact (to area and property) or value of the site		
		High	**Medium**	**Low**
Feasibility of control	Easy to control Light to medium infestation Available equipment Easy access	Very high	High	Medium
	Hard to control Heavy infestation Control methods expensive Poor access	High	Medium	Low

Source: Queensland Department of Primary Industries and Fisheries 2007. For conservation priorities also refer to Figure 3.2 in the Plan to Protect Environmental Assets from Lantana—(National Lantana Management Group 2009).

Light density lantana infestation—Yarraman, Queensland.

High density lantana infestation—Glen Ruth, Queensland.

Economic factors

Resources (both time and money)

Depending on management time frames or the availability of resources, there are three main approaches to lantana control:

1 If infestations are light or time frames for control are short—a rapid kill of lantana is desired to reduce the amount of follow-up control.

2 Where infestations are much denser or time frames are longer—initial removal of the bulk of the lantana with follow-up treatment of regrowth and seedlings is appropriate.

3 Where resources are limited—a control option that maintains or suppresses lantana until further resources are available may be most suitable.

The time invested in weed management should be considered and factored into any cost calculations. Where there is more capital to invest, more rapid control can sometimes be achieved. However, costs and time frames will generally increase as control becomes difficult due to density, access or infestation scale.

Available machinery and labour

The choice of control methods used by land managers will be influenced by the equipment available to them. Small-scale agricultural operations are often particularly limited. This is due to the size of the machinery available on their property and the fact that it is not economically viable for large machinery contractors to work on small properties. In this instance, it may be economically sensible to coordinate management work with neighbours to enable the use of large machinery and reduce cartage costs.

Other weed management

Lantana control should not be done at the expense of other weed management or weed hygiene practices and in many instances an integrated property pest management plan will enable effective coordinated management of a variety of weeds.

The integration of lantana control with other weed management may increase the initial expenditure due to the need to use a more expensive broad-spectrum herbicide; however, it often becomes more cost-efficient when the additional time and labour required to treat other weeds separately is considered. Refer to Appendix 2D for a list of other weed species that can be treated with lantana registered herbicides.

Property operations should also encourage the wash down of mechanical equipment and vehicles in areas where parthenium weed (*Parthenium hysterophorus*) or weedy sporobolus grasses (e.g. giant rat's tail grass (*Sporobolus pyramidalis* and *S. natalensis*) and giant Parramatta grass (*S. fertilis*)) are prevalent to ensure lantana management activities do not exacerbate other weed management issues. This should include contractor vehicles and machinery entering your property.

Lantana growing in conjunction with Bitou Bush.

Lantana regrowth in conjunction with Bracken Fern—Copmanhurst, New South Wales.

Climatic and environmental factors

Temperature, rainfall, elevation and seasonal effects vary dramatically across the range of lantana and affect growth patterns and seed production, which in turn affect the timing, type and success of control treatments.

Implications for control

Mechanical treatments

- Generally, mechanical control (e.g. bulldozing and grubbing) can be conducted at any time of the year but better results will be achieved if soil moisture is present. This ensures a greater volume of biomass is removed and reduces the soil disturbance compared with use in drier times.[29]
- In areas from southern Victoria to northern New South Wales that experience a more uniform rainfall across summer and winter, mechanical clearing in late winter and early summer is recommended because competitive pasture growth is almost assured.
- In subtropical and tropical climates (from coastal northern New South Wales to North Queensland), rainfall occurs mostly during the summer months. Therefore, mechanical clearing in early summer followed by the planting of summer grasses and the follow-up treatment of regrowth in early autumn is the recommended strategy.
- For more detail on mechanical control see Section 3.

Herbicide treatments

- In general, herbicide treatment must be conducted during the lantana growing season to be effective. Lantana flowering is usually considered a good indication of active growth (regardless of season). However, if herbicides with a residual capacity are to be used, consideration must be given to whether there will be follow-up rain to enable a second activation of the herbicide.
- In coastal areas of Queensland and New South Wales, flowering and fruiting occur year round,[67] allowing a wider opportunity to spray—sometimes twice in a growing season.[31]

Bobcat grubbing lantana—Tallawalah, Queensland.

Foliar spraying lantana—Elphinstone Creek, Queensland.

- In drier inland areas a distinct flush of flowering will generally occur a few weeks after soaking rain, followed by significant fruiting (4–6 weeks after a 25 mm rainfall event).[15]
- In subtropical climates, control of lantana with herbicides may be more effective in the second half of summer during flowering, especially when it coincides with post-wet season growth.
- Herbicides with metsulfuron-methyl as their active constituent (e.g. Brush-Off®; Brushkiller™; Lynx® 600) are not as effective in tropical areas.
- Herbicides with dichlorprop as their active constituent (e.g. Lantana 600) achieve a greater kill when the temperature is less then 30 ˚C.
- For more detail on herbicide control see Section 3.

Drought tolerance and frost-affected lantana

In more temperate climates, severe frosting in winter can kill the leaves and stems of lantana. While this will not generally kill the plant, it can effectively suppress lantana growth and provides significant management benefits.

- Fire management can be effectively used on dry or frost-affected lantana to remove the biomass and in some instances, kill the winter/drought-weakened root ball.
- After rains, the drought- or frost-affected lantana will shoot from the base, forming a compact ball of growth, providing an ideal opportunity for treatment with herbicides. Wait until there is at least 300 mm of active regrowth before foliar spraying.
- Alternatively, some landholders take the opportunity to grub out frosted or dry lantana plants while there is easier access to the base of the plant.

Develop a lantana calendar

Develop a lantana calendar showing flowering and fruiting times in your area. Where possible, management activities should be timed prior to fruiting to ensure there are no additions to the seed bank.

Include flowering and seeding times of native vegetation or pastures to help determine the best timing for burning, slashing and other control techniques to encourage beneficial seed recruitment.

Lantana variety and biology

There are at least 29 varieties of lantana present in Australia, all demonstrating different morphological features that affect the plant's capacity to deal with environmental conditions, the effectiveness of control techniques or its toxicity to animals.

Implications for control

Leaf size

Differences in leaf size may affect herbicide uptake. Bigger leaves often have a better chance of successfully translocating the required volume of herbicide into the plant's sap system to achieve a successful kill. Red and orange flowering lantanas often have smaller, thicker, hairier leaves than pink or white varieties; therefore, it is suggested that a surfactant is used to increase herbicide penetration on these varieties.

Seedbank

Some colour varieties are known to have a longer surviving seedbank than others. For example, experimental work demonstrates the seed of pink-edged red varieties last longer than pink flowering varieties. Unfortunately the scientific data on this is limited, but management programs should continue for at least four years to ensure exhaustion of the majority of the seedbank. In open paddock situations, deliberate soil disturbance through ploughing can be used to encourage a higher rate of lantana seed germination. Followed by active management, this ensures seedbanks are exhausted more rapidly.

Larger-thinner leaves of pink flowering lantana variety.

Smaller-thicker leaves of pink-edged red flowering lantana variety.

Toxicity

Flower colour can also be used as a general guide to toxicity level, with red varieties usually acknowledged as the most toxic while white or pink varieties are the least toxic. However, this does not hold true in all instances and advice should be sought on the toxicity of local varieties. Stock, especially animals that are new to the area, should be actively excluded from high risk varieties. Further details are provided in Appendix 6.

> "Cattle may become sun sensitive and their skin may blister after eating lantana"
>
> Mick Richards

Fire tolerance

Variable impacts of fire are more dependent on the plant's health and its ability to withstand significant stress than flower variety. Lush growth can be difficult to fire and large plants with extensive energy stores in the root system are more likely to recover after fire. Where possible take advantage of plants that are in poor health (e.g. following heavy frosts or drought periods).

Lush lantana does not burn readily.

Land use factors

Land use and vegetation communities, should strongly influence control options. Some mechanical, fire and herbicide techniques are not suitable in areas of sensitive vegetation and the cost of certain practices may not be economical.

Frequently an individual property will include a variety of land management areas for which different management techniques are required. In these instances, each area must be treated as a separate management area. Effective planning for these situations will be made easier using the Lantana Decision Support Tool (see Section 4).

Pastures and grazing

Open pastures

The choice of control methods should depend on the size of the infested area, ease of access, whether the infestations are dense or scattered, and the available resources.

Large, dense infestations

- Use initial treatments such as burning, slashing or dozing to reduce the height and density, to create access, and generate regrowth. These areas can then be more easily and economically treated with foliar applications of herbicide.[29]
- Aerial spraying by helicopter may be feasible for large infestations that are inaccessible to machinery or cannot be burnt. However, kill rates are often significantly lower than other management techniques.
- Continual follow-up treatment of regrowth and re-establishment of pasture are essential for long-term success.

Small, dense infestations

- Small, dense infestations can be treated cost-effectively by foliar spraying of herbicides from a vehicle.
- Use of splatter guns to apply concentrated herbicide solutions is also appropriate and minimises off-target damage to grasses and legumes.

Scattered clumps in grazing land—Cangai, New South Wales.

Traditional owners the Lama Lama people, involved in manual lantana control on Lilyvale Station, North Queensland.

Small, scattered infestations

- For small scattered infestations it becomes feasible to use more time-consuming methods that achieve a close to 100 per cent kill rate of adult plants in the first round of treatment.
- Applications of herbicide via cut stump, basal bark spraying and foliar spray via splatter gun are suitable for small, scattered and hard-to-access infestations.
- Alternatively, mechanical grubbing can be feasible for small infestations where access is easier and complete removal of stumps and roots is desirable. This technique generally causes less soil disturbance than pushing, but exposed soil must still be re-sown to pasture.
- Manual control methods, such as manual grubbing and hand pulling of young seedlings, can be a valuable management tool in particularly sensitive environments.

Along fence lines

Controlling lantana along fence lines will reduce the re-infestation of paddocks, and prolong the life of the fence.

- Monitor fence lines regularly for new lantana seedlings.
- Foliar spraying is usually the most effective method of control and can be done from a tractor or other vehicle.
- The cut stump method is effective for isolated clumps.

> "We find that no matter what you do, every three to four years a plant will grow up alongside a fence post. You just have to be vigilant and spot spray them when they are small and still easy to control"
>
> Landholder, Casino, New South Wales

Native pasture woodlands

Lantana can invade and dominate native pasture woodlands, particularly those that have been selectively cleared to increase grazing capacity. Once established, an understorey of lantana can be extremely difficult to control, as access is usually restricted and natural regeneration of pastures can be slow. Regular monitoring to detect new infestations is beneficial.

- Foliar application of herbicide using a hose and hand gun from a tractor or other vehicle is the control method most commonly used in this situation.
- Mechanical control methods, such as mechanical grubbing, may be possible where farm or cattle tracks exist. However, woodlands are frequently protected by vegetation management legislation and care must be taken to ensure other vegetation is not damaged.
- Low-volume applications of herbicide (e.g. splatter gun, basal barking) are effective over smaller areas.
- Native pastures under woodland should be managed so that they remain competitive and stocking rates are low enough to ensure that ground cover is maintained. Where lantana has been removed, non-invasive shade-tolerant pasture species can be sown.

Infestation in eucalypt woodland—Bonville, New South Wales.

Re-establishing pasture

Removing lantana will create opportunities for further weed invasion. Soil erosion can also result if no effort is made to regain pasture cover quickly. Bare areas should be re-sown to pasture and allowed to establish before restocking.

- Re-sow using higher than normal rates, just before rain and when the surface is still friable. Check soil fertility and apply fertiliser if necessary. Keep pastures de-stocked until pasture has established.
- If controlling with fire, ensure that vigorous improved pastures are sown after each burn and that stock are excluded until the pasture has re-established and seeded. Follow each burn with two to four years of spot spraying or mechanical control methods.
- Consult local agronomists (e.g. Queensland Department of Employment, Economic Development and Innovation or New South Wales Department of Primary Industries) for advice on pasture species suitable for local conditions.
- Do not use a pasture species that could spread into native bushland.

Re-establishing pasture.

Natural ecosystems

Lantana seed is often introduced into natural ecosystems by birds and its invasion is further enabled by human disturbance of soil or native vegetation.

Habitats that are vulnerable to understorey invasion are typically open-canopied, thus enabling the penetration of sufficient light to support lantana populations. Examples of these are open eucalypt forests and woodlands, wet sclerophyll forests and dry vine scrub (a rare type of dry rainforest).

Lantana in melaleuca swamp—Beerwah, Queensland.

Lantana infestation in open clearing in rainforest—Mount Jerusalem, New South Wales.

Bell miners and lantana

In some eucalypt forests in New South Wales, native bell miners (*Manorina melanophrys*) are flourishing in areas where lantana has infested the understorey. They feed on the sugary excretions of psyllids (sap-sucking insects that live on the eucalypts), but do not eat the psyllids themselves. Bell miners are very territorial and drive off other birds that do eat psyllids. The abnormally high populations of sap-sucking psyllids then contribute to eucalypt dieback—a condition that is responsible for the death of large areas of mature eucalypt forest.[39,78] This phenomenon is not yet fully understood, and researchers are trying to establish how best to control the lantana, balance bell miner and psyllid populations, and prevent further eucalypt dieback.[78]

Eucalypt dieback—Toonumbar National Park, New South Wales.

Rainforests have closed, multi-layered canopies with dense foliage that prevents lantana invasion when intact.[28,65] However, lantana will monopolise rainforest edges and it invades where the canopy is broken or the vegetation structure has been disturbed.[36]

Coastal areas feature a range of ecosystems including mangroves, sedge lands, heath lands, as well as dune ecosystems. Lantana will infest many of these ecosystems and can grow in sand—as long as light, moisture and nutrients are sufficient.

In the Northern Territory, lantana has recently spread along the coastal dunes and margins of monsoon vine thickets near Darwin. It is also common on headlands in Queensland and New South Wales, where it is associated with other weeds, particularly bitou bush, also a Weed of National Significance.

Lantana threatens little penguins

On Lion Island Nature Reserve at the entrance to Broken Bay, New South Wales, impenetrable lantana thickets prevented the burrowing and nesting activities of a colony of little penguins. The lantana is being removed in stages, and regeneration of native vegetation is allowing the penguins to recolonise the area.

Little penguin burrows among lantana—Lion Island, New South Wales.

Penguin in burrow.

When lantana provides habitat

Lantana can provide a substitute habitat for native wildlife. In these instances:

- remove infestations in sections, and allow natural regeneration to occur or revegetate cleared areas with appropriate native species. This allows time for native vegetation to recover and for native animals to find new habitat.
- use herbicide control methods where possible. This leaves the lantana structure intact and allows animals time to relocate to adjacent native habitat.

It is important to note that lantana negatively affects many more native species than it aids, so control to establish more suitable habitat over time should always be the focus.[50,73] Considerable research has been undertaken to identify the native species that are both positively and negatively affected by lantana. Refer to the national Plan to Protect Environmental Assets from Lantana[47] for a list of native species and communities at risk from lantana as well as a list on fauna that rely on lantana as a habitat or food resource (see www.environment.nsw.gov.au/lantanaplan/biodiversityatrisk.htm).

A total of 1322 native plant species and 158 animal species have been listed as negatively affected, compared with 142 native animal species which utilise or benefit from the presence of lantana. These lists, in conjunction with species lists for the local management area, can be used to more effectively plan management programs.

Lantana adopted as habitat.

Active revegetation or natural regeneration

The decision to revegetate with native species or allow natural regeneration to occur is largely dependent on the condition of the site. If there are very few intact native habitats in the local area to provide a seed source, revegetation is often the only option.

Revegetation

Revegetation is a long-term process that requires a commitment to continuing monitoring and follow-up control management of other invasive weeds, and protection from further disturbances.

Active replanting in a control site.

Information on appropriate replacement plant species for your area can be sought from a range of groups including BushCare, LandCare, Greening Australia, local government or the Australian Association of Bush Regenerators. Remember to consider replacement habitat structure as well as food sources for the native species that might previously have relied on lantana.

Species lists of native plants that will provide an alternative food source to fleshy fruited weed species such as lantana can be found on the Weeds CRC website at: www.weedscrc.org.au

Natural regeneration

Natural regeneration preserves the genetic integrity and diversity of the vegetation, without the costs and labour necessary for active planting. The removal of lantana can bring about a considerable regeneration of native seedlings, depending on the age of the lantana thicket and the viability of the native seed bank.

- Regeneration will be more successful where native vegetation is most intact, and infestation more recent, and when lantana management has minimal off-target impacts.
- In remnants, native vegetation can be encouraged to regenerate over time by first removing lantana from the interface of the remnant and the infestation and then clearing further into the infestation at six-monthly intervals.
- Wait at least one growing season for natural regeneration from the existing seed bank to occur. If regeneration does not occur naturally, supplement by planting local native species.
- Areas undergoing natural regeneration still need to be managed for weeds and erosion.

Using lantana as mulch

Lantana stems can be used as mulch for revegetation and erosion control. Chopping the stems will enhance their mulching ability and reduce the risk of vegetative growth from nodes in the stem. Regardless, it is important to monitor the lantana mulch for regrowth.

Do not move lantana mulch to other sites. It is illegal to transport the reproductive material of *Lantana camara* and there is a high probability that seed may be moved from one area to another with the mulch.

Lantana stems provide mulch for regeneration.

Will native seedlings grow through lantana?

Eucalypt seedlings require more light to germinate and grow than is usually available underneath lantana thickets so heavy understoreys of lantana can retard forest regeneration. On the other hand, seedlings of rainforest species can grow through lantana thickets, establishing canopy that shades lantana and reduces its viability.[64]

Native seedlings can germinate in mulched stems of lantana.

The emergence of healthy native rainforest trees from beneath lantana thickets depends on the viability of the native seed bank, the age of the lantana thicket, and the degree of disturbance that allowed the initial establishment of lantana.[28,56,58,63,64] In most situations, removing lantana will enable faster and more successful natural regeneration, as many native rainforest seedlings are found beneath most lantana thickets.[64]

Waterways

Lantana often thrives along watercourses. Though water is not thought to be a major dispersal agent of lantana seed, controlling these infestations is important for the health of riparian ecosystems, and to prevent reinfestation of other areas. On grazing land and in natural ecosystems, watercourses should be buffered by healthy riparian vegetation.

Lantana should be removed in stages, in order to prevent stream bank erosion, and to allow for revegetation with appropriate riparian species. This will help prevent further weed infestation and improve the health of the watercourse.

Mechanical and manual control

- Some mechanical controls are acceptable along watercourses, as long as disturbances to stream banks and beds are minimised and destruction of native vegetation is avoided.
- Hand grubbing is effective for small areas of lantana infestation and will cause less off-target damage and bank erosion issues than mechanical control.

Use of chemicals

- Herbicide use can be beneficial because it allows the dead stump and roots to remain in the ground, providing bank stability until other vegetation can re-establish.
- Only use herbicides that are registered for use near water bodies.
- Use low volume herbicide application methods to avoid contamination of water bodies.

Things to avoid

- Do not allow stock to trample lantana along watercourses. This will result in bank disturbance.
- Do not use fire to control lantana along watercourses. This will damage other native species and leave bare patches prone to erosion.
- Do not mix surfactants with herbicides registered for use near water bodies as this will counteract the components that make the herbicide safe for aquatic species.
- Attempt to limit the amount of leaf foliage that falls into pooled water as this will reduce the chances of fish kills due to oxygen depletion as the vegetative matter decomposes.

Creekbed infestation—Lane Cove National Park, New South Wales.

Steep inaccessible areas

Difficulty of access and the risk of erosion usually prevents the use of mechanical methods in these areas. Teams of workers can successfully carry out manual control and/or use low-volume herbicide application methods such as cut stump, basal barking or foliar spray using a splatter gun. Traditional foliar spraying (knapsack spot spraying or line spraying, using a hand-held spray gun on a retractable hose) can be viable if access allows. Biological control agents are also often relied upon to reduce the density and vigour of infestations although current agents cannot control lantana alone.

Infestation in steep country—Atherton Tablelands, Queensland.

Other methods

- Trampling by stock can reduce the height and density of infestations. Follow-up treatments, such as foliar spraying using a retractable hose and hand gun or knapsack, are necessary to do more than suppress the infestation.
- Fire can be a useful control method if native species are fire tolerant and local ground cover species grow rapidly enough to prevent erosion.
- On steep roadside embankments, fire, side slashing and spraying from vehicles are useful options.

Regulations

Currently there are many pieces of legislation, both state and local, that need to be considered when controlling lantana. Some of these may require land managers to control, suppress or prevent the spread of lantana. Other legislation or policy will limit some methods of control in areas of sensitive vegetation or when risk to property or livestock is high. Refer to Appendix 5 for further information on relevant legislation and codes.

Section 2

The lantana seven-step plan

Property pest management plan

A property pest management plan (PPMP) is essential to achieve effective coordination and integration of pest management practices. The plan:

- enables integration of pest management activities with other components of a whole property plan
- improves profitability by ensuring resources are deployed at optimum times
- promotes monitoring to track achievements and allow for operational improvements
- provides support and validation of approaches when applying for financial assistance and incentives.

A good knowledge of the distribution and density of target weeds, as well as the life cycle and attributes that promote growth and flowering or stress and leaf drop, will ultimately help target controls.

A clear understanding of what needs to be achieved and likely time frames are also vital. Options might include:

- prevention of spread
- complete removal of infestations
- active management of large infestations to make better use of the land
- slow and strategic removal of sections of an infestation to allow natural regeneration to occur.

The desired land use outcomes ultimately determine which methods are most cost-effective and will provide the most timely outcome.

A balanced approach to control should be maintained to ensure sufficient funding is devoted to follow-up management to consolidate initial investments.

Lantana control carried out in flat pasture first.

Successful lantana control in pasture.

Rainforest lantana clearing.

The lantana seven-step plan

To successfully control lantana, a seven-step plan has been developed incorporating all aspects of decision making, implementation and review of integrated control strategies. The seven steps are:

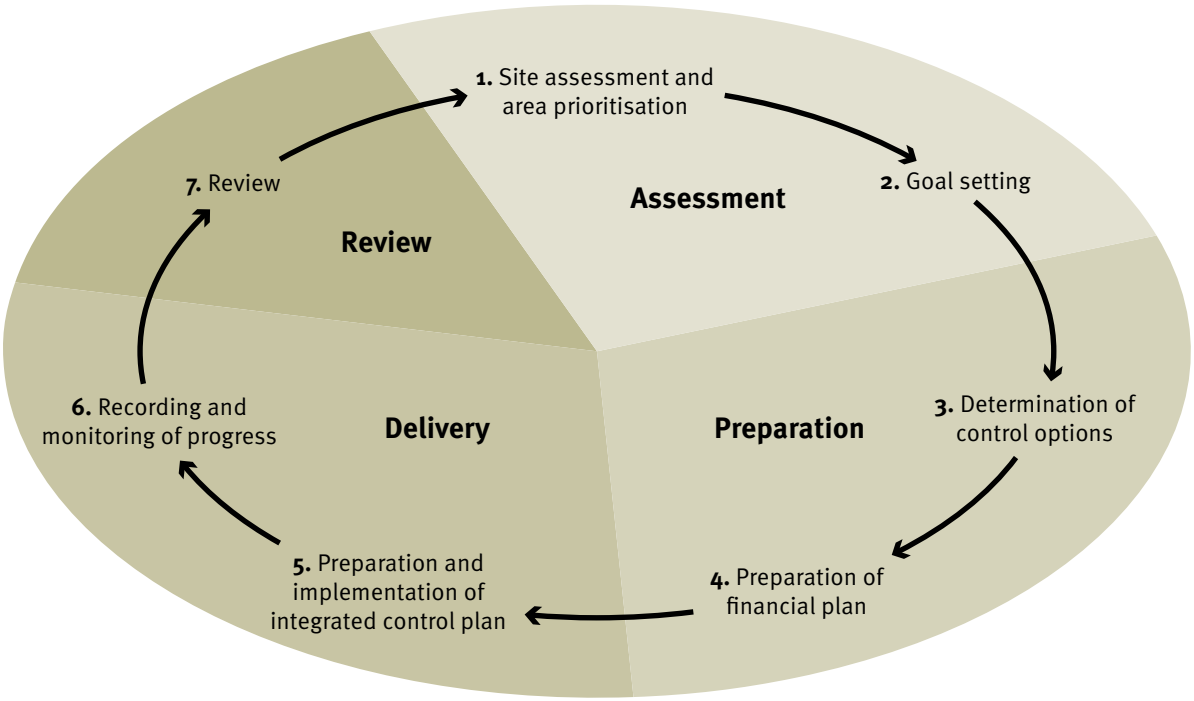


Figure 7: The lantana seven-step plan

Step 1 Site assessment and area prioritisation

The first step to any property planning is to identify areas for control and prioritise which areas need to be treated first.

Overall the decision as to which areas should be tackled first will be based on the feasibility of controlling that area and the risk or threat it poses. Areas of low impact that are difficult to control should be targeted last, while areas that pose a large threat and are relatively easy to control should be tackled first, as these areas are where the greatest return will be achieved for outlays expended.

Collecting the following details will help plan the optimum timing for control and highlight seasonal restrictions or opportunities.

Overall enterprise description and land use
Current land use • major land use • soil types • stock carrying capacity/stocking rate • cropping • conservation/timber plantation. (Can also be reordered as base map overlays)
General property details
Items and attributes • permits/licences/approvals required • agreements or covenants • easements or planning corridors • contours • remnant vegetation • drainage lines • developmental controls (e.g. local government planning conditions) • land type such as freehold, leasehold and state land (e.g. main roads, national parks, stock routes, reserves). (Can also be recorded as base map overlays)
Specific property details
Climate • average annual rainfall (including high and lows) • average temperature (including monthly high and lows) • timing of climatically important periods (i.e. common rainfall/drought periods and winter months).
Threats to property assets • weeds (species, area and density) • vectors of spread • control areas • wash-down areas • climatic conditions (e.g. drought, flooding).

Source: Adapted from Queensland Department of Primary Industries and Fisheries.[54]

Mapping

Topographic, cadastral, aerial and even hand-drawn maps can be extremely useful:

- Well-drawn maps will help track your work and progress over time and help determine where new seed sources are coming from.
- Using different overlays (e.g. for land use, topography, vegetation types) can help reduce confusion. These separate overlays can be used for future property planning decisions, such as determining new fence lines and boundaries.

Measuring lantana area and density

Lantana area

The area of the infestation can be calculated in several ways:

- For more accurate calculations:
  - use a GPS (Global Position System) unit to measure the area directly in the field or transfer the information from the GPS to a computer and use GIS (Geographic Information Systems) software to calculate the area
- For map-based estimations:
  - measure the length and breadth of the infestation or count the grid squares on your map or overlay.

Lantana density and cover (and other vegetation)

Lantana density calculation provides a reference point to base assessments of management progress over time and can be used to judge the success of controls. This information provides one of the key decision-making factors in the Lantana Decision Support Tool (Section 4). The standard mapping percentages used for Weeds of National Significance are listed below.

Table 2: Standard mapping percentages used for Weeds of National Significance (Adapted from McNaught et al 2008)

Terrestrial and aquatic weeds	
Class number	**Class description**
1	absent
2	less than 1%
3	1% to 10%
4	11% to 50%
5	greater than 50%
6	present (density unknown)
7	not known (or uncertain)
8	not assessed

Using steel pickets to mark out a 10m x 10m quadrat to monitor lantana density

Quadrat method

One of the easiest ways of measuring lantana density is by using the quadrat method. An estimate of plants per hectare can be calculated by averaging the number of plants or lantana clumps over three areas (or quadrats) of 10 m × 10 m, and then multiplying the result by 100. This provides an accurate and repeatable estimate of the overall number of plants per hectare.

When placing quadrats it is best to randomly allocate them within an infestation area. It is particularly important not to deliberately choose areas of low or high visual density as this can skew your estimates.

The above quadrat method is also useful when assessing other vegetation (for example, when measuring the recruitment of native seedlings before and after treatments and assessing the before and after density of other weeds that may invade.

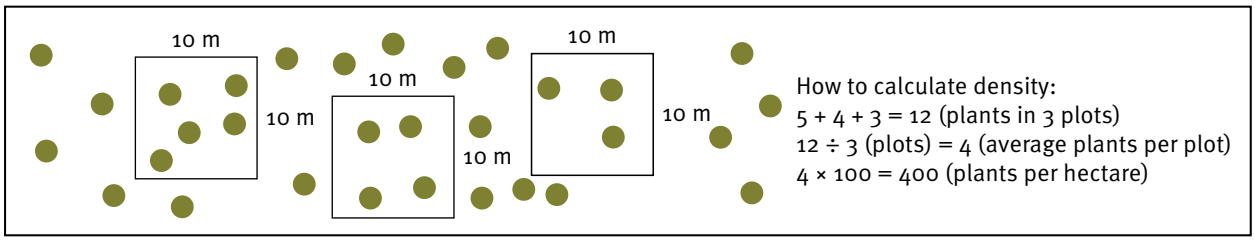


Figure 8: Measuring lantana density using the quadrat method

Measuring grass cover

Particularly in production situations, monitoring for changes in grass cover is vital for assessing the before and after effects of control and pasture improvement. Grass cover can be measured in each of the same quadrats (if applicable) as were used to measure lantana and other vegetation densities. Measurements are made by visually estimating the percentage of cover. The following figure provides a general guide.

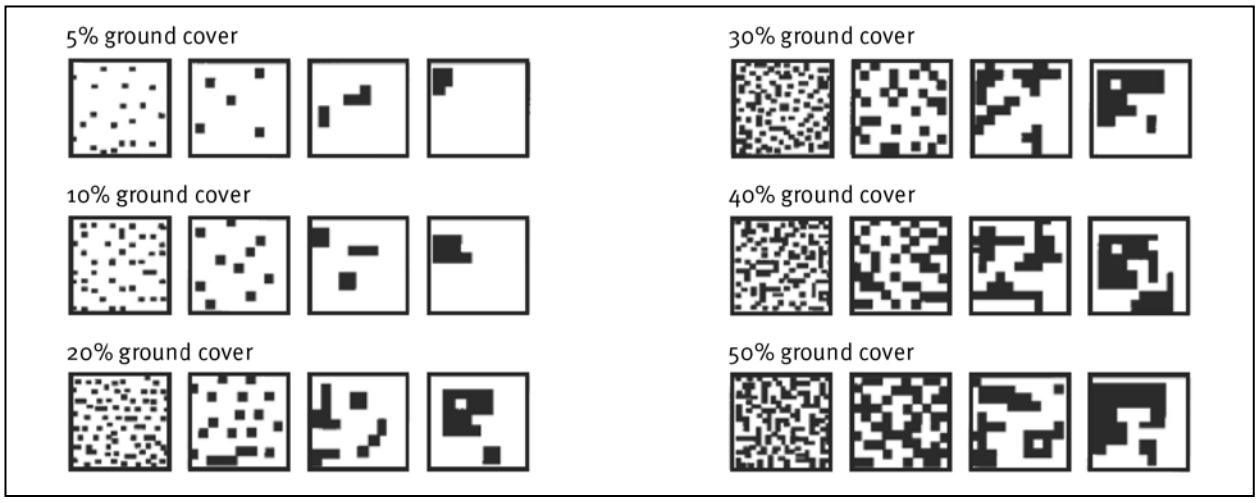


Figure 9: Guide to measuring grass cover *Source: Bayley 2001*

Step 2 Set goals

Establish clear, realistic goals before deciding on a particular control strategy. Control and follow-up carried out effectively in smaller areas is better than large-scale one-off treatments which are quickly reinfested.

Goals may be as simple as eradicating lantana in one lightly infested area or the recovery of native vegetation following lantana control in a conservation area.

Step 3 Determine control options

The Decision Support Tool (Section 4) can be used to determine the best sequence/s of control for each situation. This information will provide a guide to the expected costs and time frames associated with effective lantana management.

Before lantana control along forest edge—Nightcap National Park, New South Wales.

After lantana control along forest edge—Nightcap National Park, New South Wales.

Dense infestation of lantana in wooded pasture (December 2006)—Glen Ruth, Queensland.

Three months after spot-spraying regrowth (April 2008)—Glen Ruth, Queensland.

Step 4 Prepare a financial plan

Once an appropriate scenario has been determined using the Decision Support Tool, a financial plan should be developed.

- decide whether a contractor is necessary or management activities can be undertaken in-house (include costs of running machinery and labour)
- estimate overall costs to implement the scenario chosen (based on the estimates of costs and time per hectare from the Decision Support Tool or other local knowledge)
- determine short-term and long-term budgets based on each phase of a control scenario
- determine what equipment may need to be purchased or hired
- explore the possibilities of borrowing equipment from local councils, LandCare groups or Natural Resource Management groups
- find out if there are any financial incentives, short-term loans or other grants available that might reduce the financial burden.

Consider other relevant catchment, district or regional plans that might have implications for the property and with which cost share arrangements could be established. For example:

- regional or local government area pest management plans
- regional or sub-catchment natural resource management plans
- industry recommended management practices and codes of practice
- threatened species or ecosystem recovery plans, conservation plans
- management plans for local national parks, conservation parks and reserves.

A successful lantana control plan cannot be developed in isolation and must be integrated with everyday property activities to reduce costs and maximise results. You may need to integrate your lantana plan with other plans such as:

- resource management plans
- land and water management plans
- property vegetation management plans
- farm management systems.

Remember, follow-up management is the key to any successful lantana control program and financial planning for a full 3–4 year program will be necessary for each management area.

Local weed management strategies can assist in the coordination of strategic management programs.

Regional and state management plans are aligned with national strategic plans to ensure co-ordinated action.

Step 5 Prepare and implement an integrated control plan

A plan of action should include:

- initial control
- follow-up control
- revegetation/replanting
- monitoring
- calendar of activities that take advantage of climatically favourable periods and that attack the weed's most vulnerable life stages.

Tips

Who?	Consider developing your plan in consultation with your neighbours, nearby landholders and local groups.
	Learn about the legal requirements associated with lantana control around waterways and riparian areas and on steep land, along with the protection of native flora and fauna.
What?	Integrate strategies for controlling lantana with broader plans. Pest management plans operate at local, catchment or regional levels, and can give further guidance for the property-level planning.
	Try to integrate lantana control with other property management. If you conduct regular burning, then utilising this in your lantana management program could be advantageous.
	Choose methods of control that minimise disturbance to soil and desirable vegetation. Minimise access disturbance by using existing roads and tracks.
When?	Be flexible to allow for and take advantage of seasonal variation, remembering that most mechanical control works better when soil moisture is present and foliar spraying is only recommended on actively growing lantana.
	Adapt to circumstances such as drought, fire bans, or difficult access to infestations.
	Carry out control of other invasive weeds at the same time. Remember, herbicide choice could be influenced by the other weeds that require control (i.e. broad spectrum herbicides as opposed to lantana specific herbicides).
Where?	Always target high priority areas first.
Why?	Weeds are often a symptom of other problems, such as disturbance to soil and native vegetation by humans, inappropriate burning, overgrazing and clearing. Better outcomes can also be achieved by treating the cause of the problem.

Management plans for biodiversity

A pro forma has been developed to help land managers prepare site-specific management plans for biodiversity conservation. This pro forma can be downloaded at www.environment.nsw.gov.au/lantanaplan/implementation.htm and was developed as part of the national Plan to Protect Environmental Assets from Lantana.[47] In developing the actions and setting priorities for site management under this environmental asset plan, the key assumptions underlying effective control programs for lantana include:

- no single management technique is recommended and therefore site-specific management plans need to be developed and implemented for each high priority control site
- follow-up control is needed to prevent re-infestation and/or re-invasion. Therefore, all control programs must be long term and account for more than initial control in one year. Sources for re-infestation should also be identified where possible
- the effect of control measures on target and non-target species needs to be considered.

Revegetation/pasture establishment

Revegetation with native or pasture species immediately after control is essential. Pasture or native vegetation may regenerate naturally, but active replanting may be necessary where the pasture/native seed bank has been depleted. Follow-up is still likely to be necessary for some time.

In conservation areas always try to replant with locally sourced native species to maintain the genetic integrity of the system. Ensure you plant with appropriate species to represent the vegetation type you are trying to restore. Consider the habitat and food requirements of the native fauna that rely on the system for survival and, where necessary, consult a local bush regenerator to find out the best plants for your area.

In agricultural areas, ensure replacement pasture species do not include varieties that have the potential to become weedy if they are not intensively grazed. Plant responses vary from area to area, so consult a local agronomist to find out the best pasture species for the site and situation.

Work should occur across boundaries.

Pasture establishing.

Step 6 Record and monitor progress

There are two main reasons for monitoring:[54]

1 Operational: assessing impacts of weeds, measuring effectiveness of control methods, determining when to carry out control programs and for adaptive management

2 Performance: checking that management aims are being met, and action plans have been carried out.

Monitoring is also useful for keeping track of the cost of different methods for comparison and reporting to financial organisations or funding bodies. To make more efficient use of time, monitoring can be incorporated into follow-up activities.

It is important to make an assessment at each stage of the integrated control program to keep track of the progress and adjust techniques as required.

The following monitoring tools can be used:

- maps
  - document expansion/reduction of infestations against property management priorities
- photo monitoring
  - provides an easy 'visual' method of assessing progress over time
  - also helps document the size and condition of the lantana at time of control
- keep a log of activities, dates, climatic and environmental factors
  - helps determine why some methods may have worked one year but not in another
- assess costs through records of expenditure and revenue
- keep records of herbicides used
- record failures as well as successes
  - important to ensure ongoing improvement and development of farm-based management practices.

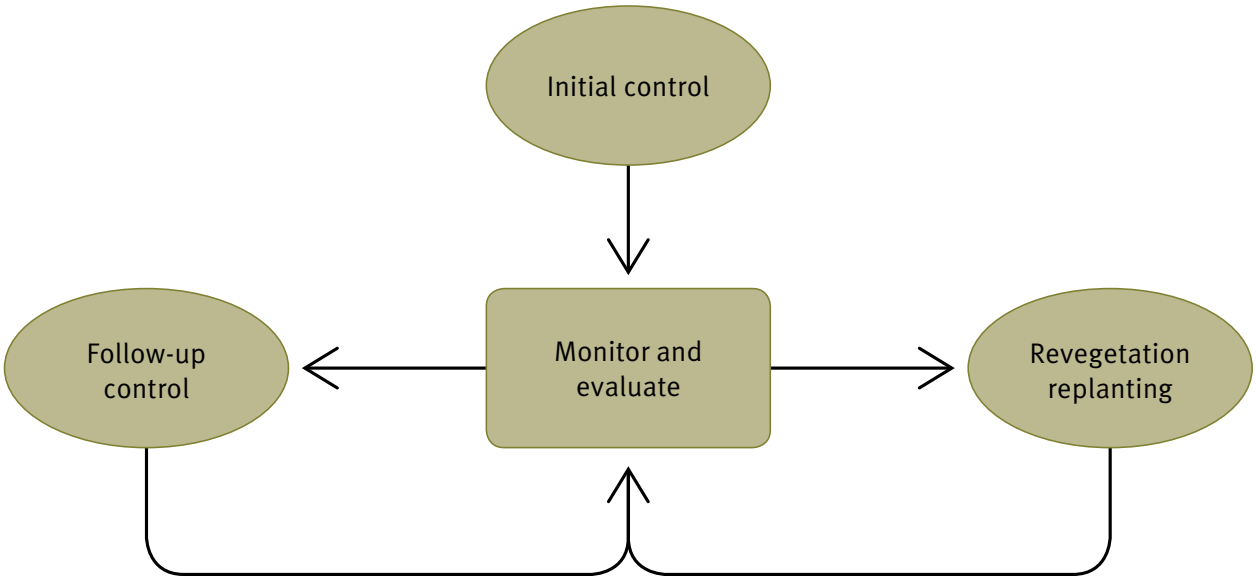


Figure 9: Stages of the integrated control program

Monitoring guidelines are being developed that provide a standardised methodology to measure the response of lantana to control and the recovery of native plant species at risk. These guidelines have been tested for lantana and will be used for the Plan to Protect Environmental Assets from Lantana.[47]

Establishing photo monitoring points

When set up correctly, photo monitoring can be one of the cheapest and most reliable records of progress. It takes little capital cost and time to set up, requires virtually no technical skill and causes little to no disturbance of the site.

To establish photo monitoring points:[45,53]

- first, mark out with a star picket the location where the photo will be taken
- use a camera post around 1.5 m high on which to rest the camera
- align the photo in a north-south direction to avoid excessive sun or shadow and where possible, have the sun behind you when taking photos
- take photos on a clear day between 9 am and 3 pm (avoid taking photos in the middle of the day as this causes downward shadows)—this will reduce shadowing and colour variation
- where possible, include distinct objects in the photo to provide a basis for comparison (e.g. a significant tree or piece of infrastructure)
- use the same camera and settings each time
- take photos as frequently as needed to show changes
- try to take photos at the same time of year for annual comparisons.

Step 7 Review plans

Key questions:

- Was the plan implemented? If not, why?
  - lack of time
  - low resource availability
  - weather conditions.
- Did you achieve your outcome? If not, why?
  - poor herbicide death due to application error
  - soil too dry
  - did not remove enough biomass with bulldozer.
- Was the cost over or under budget?
- Did the control sequences suit the situation?
  - did it effectively control lantana?
  - did you have the right equipment?
  - were the weather conditions applicable to the controls?
- Were there any positive or negative changes in the condition of the property as a result of the management tasks?
  - increased carrying capacity/stocking rate in previously lantana-filled paddock
  - return of native species previously suppressed by lantana.
  - identify what you could have done differently.

Where management outcomes were not as successful as expected, determine why and where possible adjust management plans to overcome barriers to success.

Section 3

Control methods

Integrated control

Unfortunately there is no single control regime for lantana that suits every management situation. A range of control methods are available—each with its own inherent limitations that need to be managed.

Integrated control combines two or more methods, targeting vulnerable aspects of the weed and different points in its life cycle in order to achieve more effective control. By integrating a range of management practices, the limitations of any one technique can be overcome and, when combined with sustained follow-up management and revegetation (when necessary), lantana can be effectively controlled in most landuse situations.

Integrated control:

- enables management activities to be undertaken at different times of the year
- takes advantage of the weed's vulnerabilities and can achieve increased management effectiveness through the compound effects of a sequence of control actions
- ensures tolerances to specific herbicides do not develop (i.e. herbicide resistance).

Appropriate integrated control management sequences will be highlighted through the use of the Decision Support Tool (see Section 4). The following section provides basic information on each of the key management techniques.

Manual control methods

Manual methods such as hand grubbing and hand cutting may be suitable where infestations are hard to access with machinery and equipment; for the protection of certain threatened species; or where there is a desire to avoid the use of chemicals.

Compared with mechanical techniques, manual control methods minimise disturbance to the soil and desirable vegetation, and lower the risk of both erosion and germination of lantana and other weed seed. Manual methods are generally more labour intensive than other techniques. However, teams of workers can gain access to areas where machinery and vehicles cannot, and they can quickly remove lantana over large areas. Sturdy gloves, a long-sleeved shirt, long pants and eye protection should be worn to avoid scratches, blisters and eye injuries.

Shallow mat-like root system.

Hand pulling and grubbing

Hand pulling seedlings is often useful as a follow-up treatment. It is most effective after rain when the soil is moist. A mattock, chip hoe or lever can be used to remove larger plants, including their root system, from the ground. Depending on the situation, pulled lantana plants can be hung upside down in surrounding trees or rolled to expose the roots and ensure the plant does not reshoot.

Advantages	Disadvantages
Effective for removing isolated plants.	Not suited to control large infestations.
Minimises risk to native flora.	Time consuming.
Beneficial where chemical use is not desired.	Labour intensive.
Little regrowth following the use of this technique.	

Timing

- Works best when soils are moist. This minimises required effort and maximises the likelihood of removing whole plants.
- Seedlings can be hand pulled any time.
- Adult plants should be pulled/grubbed before they have a chance to seed as this will prevent further additions to the seed bank.

Sturdy gloves should be worn for manual control methods.

Using a mattock to grub out roots.

Hand cutting

Hand cutting with a powered brush-cutter can create access into heavy infestations for carrying out other control. Hand-held brush hooks or machetes can also be used. A method popular with landholders on smaller properties is to use strong secateurs or hedging tools to cut lantana stems into small pieces for use on site as mulch. When the main thicker stems or basal stems are reached, the plant can be grubbed out or cut and painted with herbicide (the cut stump method). Larger plants' root systems can be left in the ground to assist with stabilisation and to prevent erosion. The cut stems can serve as mulch for revegetation on site, but careful monitoring for regrowth and seedlings is necessary and mulch should not be transferred to other sites due to the risk of seed spread.

Advantages	Disadvantages
Effective in removing isolated plants.	Not suited to controlling large infestations.
Minimises soil disturbance.	Time consuming.
	Labour intensive.

Timing

- Can be done any time of the year.
- Adult plants should be cut before they have a chance to seed as this will prevent further additions to the seed bank.

A variety of manual control tools are typically used for lantana

Machetes are useful for hand cutting.

Chemical control methods

The product trade names in this publication are supplied on the understanding that no preference between equivalent products is intended or implied and that the inclusion of a product does not imply endorsement by any state or federal government agency over any other equivalent product from another manufacturer.

Control with chemicals (herbicides) can be a practical, effective and efficient component of a lantana-integrated control strategy. Their use can be cost-effective for smaller infestations and for treating regrowth, but less so for extensive infestations.[44]

Like all lantana control it is important to plan a herbicide program, taking note of personal and environmental safety, compliance with the law and herbicide labels. It is also important to note that some herbicides are registered for use at different volumes or concentrations depending on plant size or state regulations.

Herbicides allow safe and simultaneous use of the land (with some stock withholding periods) and provide a management option (using aerial application or splatter gun techniques) for sites where dense lantana or vegetation prevents the use of other management methods. Herbicides also minimise the disturbance of natural vegetation and soil, thereby minimising germination and invasion by other weeds.

Under most circumstances, herbicides will not provide a 100 per cent kill and follow-up control will be required.

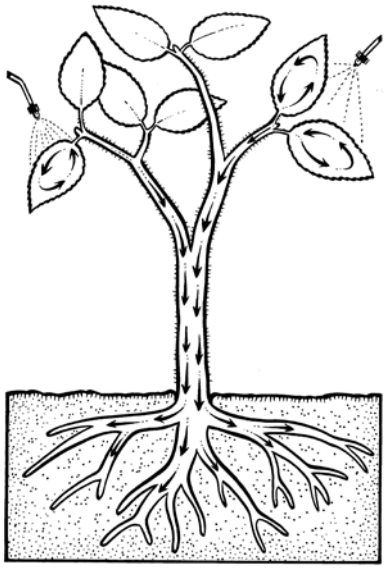
However, there are many situations where the use of herbicide should not be the first or the only method considered (for both economic and environmental reasons). Use of the Lantana Decision Support Tool will help identify these instances.

General herbicide rules

General advice may vary between herbicides. Therefore, any use of these recommendations should be in strict accordance with the label directions for the herbicide being used.

Technique

- Foliar spray techniques (other than splatter gun) require herbicide application to thoroughly wet all foliage and stems to the point of run-off. Use a nozzle configuration and pressure that ensures canopy penetration.



Herbicide can only be moved through actively growing plants

Plant condition and size

- In most instances it is recommended that herbicides are not used on stressed lantana as a reduced level of control may result. Stress can result from prolonged periods of extreme cold, moisture stress (water logging or drought), poor nutrition, presence of disease, heavy insect attack or previous herbicide treatment.
- Some herbicides (e.g. fluroxypyr) may still achieve good control even with poor foliage cover due to health stress or biocontrol impacts, but only by using the highest registered rate.
- Regrowth should be at least 300 mm in height before spraying.

Regrowth too small to spray.

Environmental conditions

- Apply herbicides when soil moisture is readily available.
- Do not spray if rain is predicted within 4–6 hours when using 2,4-D or glyphosate; or within one hour when using fluroxypyr +/– aminopyralid and picloram + triclopyr. Delay treatment until after heavy dew or when water droplets fall off the leaves when touched. Heavy rain soon after application is likely to wash any chemical off the leaves and produce a poor result.
- Do not use herbicides during times of high wind (› 15 km/h)—when spray drift onto nearby susceptible plants is likely
- Do not use herbicides when temperatures are above 35 °C.
- Treatment should be delayed until after any annual flooding as the residual impacts of herbicides will be lost.

Regrowth suitable to spray.

Healthy mature lantana ready to spray—Tazali, Queensland.

Application timing

- Spray lantana in the best season according to product guidelines and, as a general rule, only when it is actively or vigorously growing. Flowering is a good sign of active growth. Late summer to first frost [February–June] generally gives better translocation of herbicides to the roots resulting in better kills than spring to early summer.
- In different climatic areas the windows of opportunity for spraying will vary. Even on the same property it may be possible to spray lantana in moist gullies beyond the time when lantana in open fields can be sprayed. Use plant condition as an indicator.
- For best results, apply herbicides in the cooler times of the day when evaporation will have less effect.
- For some herbicides (e.g. Grazon® Extra, Access®, Brush-Off®), delaying burning, cutting or clearing for six months after spraying is recommended in order to maximise the chance of the herbicide achieving a kill.

Other considerations

- Plan to control other weeds while carrying out lantana management (see Appendix 2d for control options).
- Remember the importance of following up and monitoring for regrowth and seedlings as part of your control program.
- Although herbicides have been used successfully to control lantana in Australia for many years, there is little data available about the impact of herbicides on native flora and fauna.[47]

'Old man' lantana (plants that have been well established for many years and are generally taller than 2 m) are difficult to control with herbicides. Most herbicide labels suggest the use of higher rates for foliar spraying or the initial use of mechanical control before herbicides are used for the treatment of regrowth.[20]

Old man lantana—Yarraman, Queensland.

"We find that plants take up herbicide very poorly when they are stressed by drought, but we have excellent results when there is enough moisture for them to be growing, and when they are flowering"

Landholder, Boona, Queensland

Selective and residual herbicides

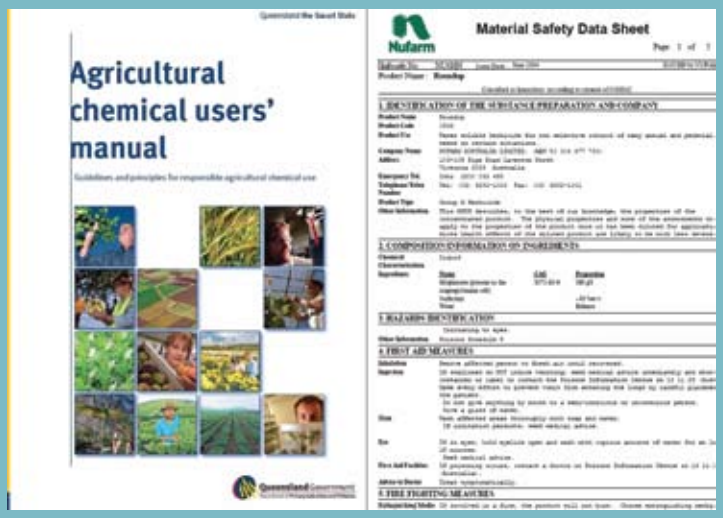
Some herbicides are selective and at registered application rates will kill lantana without affecting pasture, eucalypts and other selected plant species. Information on selectivity is provided on the herbicide label. However, the list of species affected by the herbicide will not be exhaustive and care should always be taken. Further information may be available from herbicide company representatives.

Other herbicides have a residual capacity and remain active in the soil some time after application. This enables the control of new lantana seedlings as they germinate, or continued action on adults in the next active growth period.

A list of selective and residual herbicides is provided in the table below.

Table 3: Selective and residual herbicides

Active constituent	Examples	Soil residual	Withholding period	Species affected				
				Lantana	Eucalypts	Acacias	Legumes	Grasses
picloram + triclopyr + aminopyralid	Grazon® Extra	✓	nil	✓	✓	✓	✓	×
picloram + triclopyr	Grazon® DS, Conqueror®	✓	nil	✓	✓	✓	✓	×
aminopyralid + fluroxypyr	Hotshot®	✓	nil	✓	×	✓	✓	×
fluroxypyr	Starane® Advanced, Flagship® 200	×	7 days	✓	×	✓	✓	×
dichlorprop	Lantana 600	×	n/a	✓	×	×	✓	×
2,4-D amine	Amicide® 625	×	7 days	✓	✓	×	✓	×
glyphosate	Roundup®, Ripper® 480	×	nil	✓	✓	✓	✓	✓
triclopyr	Garlon® 600	×	nil	✓	✓	✓	✓	×
picloram ester + triclopyr ester	Access®	✓	nil	✓	✓	✓	✓	×
metsulfuron methyl	Brush-Off®, Brushkiller™	✓	nil	✓	✓	×	✓	✓
picloram (gel)	Vigilant® Gel	✓	nil	✓	✓	✓	✓	×
picloram + 2,4-D	Tordon® 75-D	✓	7 days	✓	✓	✓	✓	×



Safety and legislation

By law, only herbicides registered with the Australian Pesticides and Veterinary Medicines Authority (APVMA) can be used (refer to www.apvma.gov.au). All herbicides must be applied in accordance with label instructions or off-label permits. The herbicide label and Material Safety Data Sheet are provided for your health and safety.

For a full list of all the active constituents currently registered for lantana see Appendix 4.

To use herbicides in any manner not stipulated by the herbicide label, an 'Off-label permit' must be obtained from the APVMA.

To ensure personal safety you should:

- wear personal protective clothing and use equipment in accordance with the manufacturer's label recommendations. This may require wearing full head and body covering with respirators and filters, and impermeable boots and gloves
- minimise exposure to herbicides when mixing by wearing elbow-length PVC gloves and a face shield
- keep equipment leak-free and in good working order
- use equipment that meets Australian standards
- spray only in ideal wind and weather conditions to reduce drift, and avoid spraying into the wind.

Keep first aid equipment on hand and have an adequate knowledge of appropriate procedures. You should:

- treat any personal contact with chemicals immediately by washing the skin or contacted area and seek medical advice.
- remove contaminated clothing, hats and shoes and wash separately from other clothing.
- recognise over-exposure symptoms requiring urgent medical attention (such as nose bleeds, skin irritation or nausea).

Personal protective equipment must be used for chemical control methods.

Spraying lush flowering lantana—Tallawalah, Queensland.

Table 4: Poisons schedule

Schedule level	Toxicity	Signal words present on product label
Schedule 7	Extremely toxic	Dangerous poison
Schedule 6	Moderately toxic	Poison
Schedule 5	Toxic	Caution
Unscheduled	Low toxicity	No signal heading required; 'Keep out of the reach of children' only.

It is a legal requirement to keep detailed records of herbicide use (see Appendix 3 for Herbicide Distribution Record information—a record template has been provided for your convenience).

Training and certification

Under most circumstances a permit is not required for the use of herbicides on private property as long as the user adheres to label and existing permit restrictions. However, there are exceptions to this rule (for example, permits are required for using 2,4-D n-butyl ester in certain areas of south-east Queensland). It is advisable to check the herbicide label or with the local authority to be certain.

Contract spray operators or individuals spraying on public land or someone else's property *will* require a licence:

- In Queensland, a 'commercial operator's licence'—commonly know as an ACDC licence—is required under the *Agricultural Chemicals Distribution Control Act 1966*. These licences are issued by the Department of Employment, Economic Development and Innovation.
- In New South Wales, the *Pesticides Act 1999* requires all commercial operators to be trained in pesticide application, with a minimum AQF2 unit of competency (applying chemicals under supervision).
- For all other states please check with your local authority.

For more information regarding record keeping, notification requirements and training in the use of herbicides and pesticides, contact your state government or refer to the appropriate legislation.

High volume herbicide application

Foliar spraying (ground)

Foliar spraying is the application of a fine spray of low concentration herbicide solution to leaves and stems to the point of run-off (i.e. until every leaf is wet). If full coverage is not achieved it dramatically reduces the chance of controlling the whole plant (e.g. failure to cover side laterals and top growing points from at least two opposite directions of large clump will ensure its survival).

Herbicides work better on smaller plants and regrowth, as fresher leaf material will allow greater absorption of herbicides into the plant's sap stream.

Advantages	Disadvantages
Application of herbicide is quick and accurate if equipment is correctly calibrated. Provides selective control with appropriate herbicides. Cost-effective for smaller infestations and for treating regrowth. Minimises soil disturbance. Allows pasture to replace bare soil. Enables simultaneous use of land (some withholding periods apply).	Herbicides may cause off-target damage. Can be costly for extensive infestations. Technical proficiency required. Vehicle hygiene risks (potential for weed seed spread). Generally only works when lantana is actively growing. Difficult to foliar spray dense lantana and lantana growing into tree canopies as adequate coverage cannot be achieved. Potential for spray drift.

Timing

- Works best when plants are actively growing to maximise herbicide transfer to plant's roots.
- Reduced control would be expected if spraying drought or frost affected lantana.
- Best time for foliar spray from January to April.

Knapsack

This method involves a low pressure foliar spray delivered via a hand-held container (usually 15 litres or less) with a spray nozzle. The registered application volumes and rates are the same as for hand gun foliar spraying.

- This method allows delivery on foot or by quad-bike where access by vehicles may be restricted.
- It is useful for spot-spraying seedlings and regrowth up to 500 mm where only small volumes of herbicide are required.

Hand gun, hose, reel and tank

High-pressure foliar spray using a hand gun is a common technique for spraying lantana over larger areas. Vehicles that have retractable hoses and pumps loaded, such as Quikspray® units, are favoured for the delivery of high volumes of herbicide mix.

- This method is useful to obtain maximum spray coverage of plants where vehicles can access the spray area.
- High pressure foliar spray is likely to achieve application of herbicide in the quickest time frame.

Aerial spraying

This method involves herbicide application using a boom mounted on a helicopter (herbicides for lantana control are not registered for application by a fixed-wing aircraft).

Advantages	Disadvantages
Good where dense lantana prevents the use of other conventional methods.	Applicability depends on low winds to avoid likely spray drift.
Can cover large areas very quickly.	Can be costly at more than $1000 per hour plus ferrying costs.
Requires less mix per hectare than conventional spraying.	When using non-selective herbicides, there may be off-target damage.
May be economical for controlling large areas of dense lantana in open areas.	Seasonally restricted—ideal conditions required to achieve a good result, with follow-up always required.
Minimises direct soil disturbances.	Achieving adequate coverage can be problematic when lantana is associated with large non-target vegetation.
Good for large infestations that are inaccessible to machinery or cannot be burnt.	
Spray configuration allows accurate application of herbicide.	

Timing

- Aerial spray between January and April, but can be done earlier in the season if plants are actively growing.
- Reduced control would be expected if spraying drought or frost affected lantana.

Method:

- Always spray with a properly calibrated boom to ensure adequate coverage of the target infestations.
- Higher concentrations of herbicide are used for aerial application compared with standard foliar spray techniques (refer to *Using herbicide on lantana* booklet, included in accompanying CD).
- Ensure nozzles are set to produce coarse to very coarse droplets to avoid spray drift.
- Use a half overlap, opposite pass technique to ensure lantana is sprayed from two different directions, as this will ensure maximum coverage.
- Do not apply herbicide aerially if wind speeds are less than 3 km/hr or greater than 15 km/hr and air temperatures are above 35 °C.[51]
- Glyphosate is registered for aerial spraying of woody weeds. However, this herbicide is not recommended for aerial use on lantana as the registered rate (4 L of glyphosate 360 g/L/ha) is not sufficient to control lantana and as glyphosate is a non-selective herbicide, the risk of damage to surrounding vegetation is extremely high.

Low volume, high concentration applications

Low volume methods deliver small volumes of high concentrate herbicide mixture to plants to reduce chemical usage and off-target damage. Consequently, they are particularly useful in environmentally sensitive situations where herbicide run-off is likely to affect adjacent plants or enter water systems.

Advantages	Disadvantages
Can be used when treating lantana in sensitive areas as well as in production situations.	Cannot be used in wet weather.
Good where dense lantana prevents the use of other conventional methods.	Low effectiveness on plants with heavy dew.
Good where inaccessibility or restrictions on vegetation clearing means mechanical methods cannot be used.	Difficult to apply to spindly lantana regrowth.
Small volumes of herbicide reduce chemical usage.	
Accurate delivery improves targeting of weeds, and as only a small portion of the foliage needs to be sprayed off-target damage can be avoided.	
Can be used from a vehicle, from horseback or on foot.	
Low water volume requirements make the device easily portable so larger areas can be covered than with traditional foliar spray techniques.	

Timing

- Can be used all year round but works best during summer months when plants are actively growing, which maximises herbicide transport to plant's roots.

Splatter gun

The splatter gun (or gas gun) control technique involves the low volume, high concentration application of herbicide to lantana foliage. This technique is particularly useful in areas of difficult access or sensitive vegetation and can be cheaper and more effective than alternative herbicide application techniques.[71]

Method:

- This technique works best on thick clumped lantana of at least 300 mm height or scattered regrowth with a compact growth form.
- Ensure the splatter stream nozzle is attached. Splatter guns also come with a fan nozzle that will not provide adequate results using concentrated herbicide.
- To apply, angle the spray gun at 45 degrees and arc the stream of herbicide over the top of the bush and down the front face.
- If treating dense walls of lantana, apply one vertical spray line every two strides, with an occasional horizontal pass low across the front face of the bushes to treat any low growth.
- Apply approximately 15–20 mL per splatter of 100 mL glyphosate (360 g/L) per litre of water on large bushes of 1.5–2 m in height to achieve the registered rate of 2 × 2 mL of herbicide mix per 0.5 m of bush height.
- Do not apply more than the registered rate of herbicide as this can put the plant into shock and the herbicide will not be transferred to the rest of the plant leading to poor control.
- Surfactants are usually unnecessary but a marker dye can help identify which areas have been treated.

Stem applications

These methods involve the application of concentrated herbicides and/or diesel to the freshly cut stump or lower trunk of the lantana bush. These techniques are more time consuming but provide reliable control and can be useful where options are limited by the risk of off-target damage or the poor condition of the lantana plants.

Advantages	Disadvantages
Reduced soil disturbance.	Labour intensive and time consuming.
Reduced herbicide use.	Care is needed to control each stem on multi-stemmed plants.
Reduced risk of off-target damage.	Can cause suckering from roots.
Useful on slopes and riparian areas (mainly cut stump) as it retains stump roots in the ground to help prevent erosion.	Cannot be used on charcoal-coated or wet stems as this will repel the diesel mixture.
Good for controlling stands of a few shrubs.	When using triclopyr (e.g. Garlon® 600) it is recommended that you do not burn, cut or clear for 6 months after spraying.
Can be used all year round and on moderately stressed plants.	Vigilant® Gel is not totally rainfast and should not be applied if rain is expected within 12 hours of treatment.
Effective on plants that have been defoliated by biological control agents.	
Can be useful for larger plants that cannot be effectively treated by foliar spraying.	

Timing

- Can be used all year round and on stressed and drought affected lantana. Works best when plants are actively growing to maximise herbicide transport to plant's roots.

Machete to cut stump.

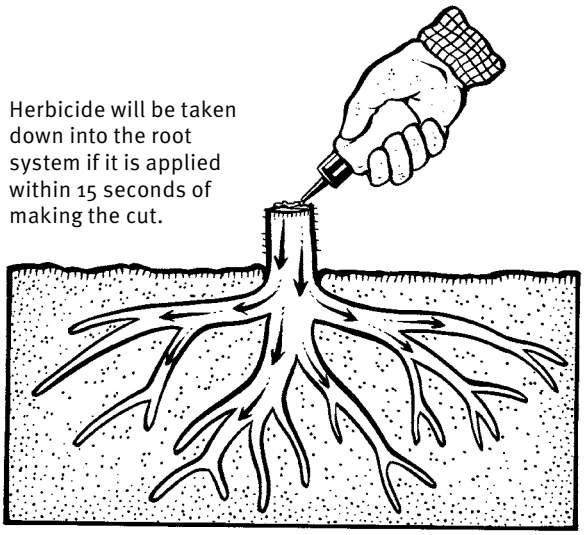
Hand saw to cut stump.

Cut stump

This technique involves low volume, high concentration herbicide application to the freshly cut stumps of lantana plants.

Method:

- Cut the stems off completely no higher than 15 cm above the ground and apply the concentrated herbicide within 15 seconds. If herbicide application is delayed the plant will seal the cut and the chemical will not penetrate to the sap. Two workers can carry this out more effectively than one.
- Picloram gel (Vigilant) must be applied to stems cut 2–5 cm above the ground and within 5–10 minutes of cutting.
- Stems may be cut with a chainsaw, handsaw, axe, brush-cutter or machete and the herbicide sprayed from a knapsack, hand-held spray bottle, drench gun, or painted onto the cut stump with a brush.
- All stems must be treated, as lantana plants regrow vigorously from untreated cut stems.



Herbicide will be taken down into the root system if it is applied within 15 seconds of making the cut.

Knapsack sprayer to apply herbicide.

Brush to apply herbicide.

Spray bottle to apply herbicide.

Cut, scrape and paint method

The cut, scrape and paint method is a variant of the cut stump method that requires more effort but is often more effective.

Method:

- Cut the stump close to the ground and apply concentrated herbicide within 15 seconds (as per the cut stump method).
- Using a knife, scrape the sides of the stump lightly to reveal green tissue.
- Apply concentrated herbicide with a paintbrush within 15 seconds.
- Take care not to contaminate the brush with soil, as this will reduce the effectiveness of the method.

Cut.

Paint.

Scrape.

Painted stumps with dye—Berry, New South Wales.

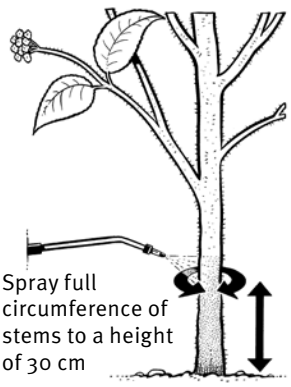
Basal bark application

This technique involves the application of herbicide mixed with diesel directly to the lower trunk and lower branches of the lantana plant—similar to a form of chemical ringbarking.

Knapsack sprayer to apply herbicide.

Method:

- Use an oil-soluble herbicide mixed with diesel (see *Using herbicide on lantana* booklet, included in accompanying CD, for details of herbicides registered for this technique).
- Paint or spray herbicide mix at low pressure around the circumference of all stems, from the ground to a height of around 300 mm.
- Every stem must be saturated to the point of run-off.
- Old, rough barked stems need more spray than young stems[17] and should be treated at least up to, or just beyond, the first branch.
- The herbicide solution should not be applied to wet or charcoal coated stems, as this can repel the diesel mixture.



Penetrants and surfactants

The addition of penetrants and surfactants (adjuvants) to some herbicides may increase the herbicide absorbtion into the lantana's sap system. Surface wetting agents reduce the surface tension of water and increase the herbicide's spreading or wetting properties. This may be particularly useful for thicker, hairy leaved lantana varieties such as red, pink-edged red and orange flower types. Some adjuvants are designed for use with specific herbicides. Please read the label carefully. Certain herbicides (e.g. Grazon® Extra, Garlon® 600, Hotshot® and Starane® Advanced) already contain surfactants and further additions are not recommended unless detailed in the label.[20]

Some commonly used adjuvants are:

- non-ionic organosilicone penetrants/surfactants such as Pulse® Penetrant or Input®
- non-ionic alcohol alkoxylate surfactants such as Chemwet® 1000 or Wetspray® 1000
- spraying oils such as Uptake® Spraying Oil
- specially designed surfactants for use with specific herbicides such as Bonus®.

Penetrants and surfactants should *not* be added to herbicides that are registered for use around waterways as they will counteract the components that make the herbicide safe for aquatic species.

Dyes

Manufacturers and herbicide users recommend using a marking agent. Dyes should be used to mark areas already treated, to ensure that an adequate volume has been sprayed and areas are not missed.

Other important information

Mixing herbicides

- Only some herbicides registered for lantana control are compatible (see recommended tank mix partners in Table 5). Non-compatible herbicides can result in reduced control, cause excess foaming, form precipitates in the tank and clog spray nozzles.
- Ensure clean water is used when mixing. For example, a reduced result will occur if using glyphosate with water containing suspended clay or organic matter or high levels of calcium, magnesium or bicarbonate ions.
- For some herbicides, reduced results can occur if mixed with hard water (i.e. water containing soil or calcium salts).[51] Refer to herbicide labels for specific information.
- Always add a surfactant/wetting agent to metsulfuron methyl herbicides (e.g. Brush-Off®) to achieve good control.[22] Adding surfactants when tank is nearly full will avoid excessive foaming.
- When preparing herbicides mixes, half fill the tank with water/or diesel then add the required amount of herbicide before completing the fill. Agitate the mixture when tank is sealed or by circulating mix through bypass/spray hoses to ensure the correct mix reaches the nozzle/s.
- Some herbicides require agitation to keep active ingredients in suspension (e.g. Brush-Off®).[22] However, it is important to follow label instructions as this can create excessive foaming.
- Carefully select mixing containers to suit the herbicide being used. Some herbicides, such as metsulfuron methyl and glyphosate, cannot be mixed together in galvanised steel or unlined steel containers as this will produce hydrogen gas and a potentially explosive mixture.[22,52] Other herbicides may have corrosive effects on aluminium.[52]
- Only mix herbicide in quantities that are likely to be used in one day, and use promptly. Some herbicides, such as Grazon® Extra, Starane® Advanced and Tordon® 75-D, can remain in diluted form for up to one week while others cannot be stored for more than two days (e.g. metsulfuron methyl)[22]. Some herbicides (e.g. Lantana 600) cannot be stored for in direct sunlight.[4]

The following is the recommended order to mix herbicides in water:

1. wettable powders or dry flowable formulations (e.g. Brush-Off®)
2. suspension concentrates (flowables)
3. water soluble salts (e.g. Tordon® 75-D, Amicide® 625)
4. emulsifiable concentrates (e.g. Starane® Advanced)
5. if required, add surfactants and penetrants last to minimise foaming.

Table 5: Compatibility chart—Recommended tank mix partners

Active constituent	Example of commercial products	picloram + triclopyr + aminopyralid	picloram + triclopyr	aminopyralid + fluroxypyr	fluroxypyr	dichlorprop	2,4-D amine	glyphosate	triclopyr	picloram ester + triclopyr ester	metsulfuron methyl	picloram (gel)	picloram + 2,4-D
picloram + triclopyr + aminopyralid	Grazon® Extra		✓	✓	✓	✓	✓	✓	✓	×	✓	×	✓
picloram + triclopyr	Grazon® DS, Conqueror®	✓		✓	✓	✓	✓	✓	✓	×	✓	×	✓
aminopyralid + fluroxypyr	Hotshot®	✓	✓		✓	✓	✓	✓	×	×	✓	×	✓
fluroxypyr	Starane® Advanced, Flagship® 200	✓	✓	✓		✓	✓	✓	✓	×	✓	×	✓
dichlorprop	Lantana 600	✓	✓	✓	✓		✓	✓	×	×	✓	×	✓
2,4-D amine	Amicide® 625	✓	✓	✓	✓	✓		✓	✓	×	✓	×	✓
glyphosate	Roundup®, Ripper® 480	✓	✓	✓	✓	✓	✓		✓	×	✓	×	✓
triclopyr	Garlon® 600	✓	✓	×	✓	×	✓	✓		✓	×	×	✓
picloram ester + triclopyr ester	Access®	×	×	×	×	×	×	×	✓		×	×	×
metsulfuron methyl	Brush-Off®, Brushkiller™	✓	✓	✓	✓	✓	✓	✓	×	×		×	✓
picloram (gel)	Vigilant® Gel	×	×	×	×	×	×	×	×	×	×		×
picloram + 2,4-D	Tordon® 75-D	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	×	

Cleaning

- Clean all equipment by thoroughly washing with water for at least 10 minutes (or as per the label directions) and clean tanks by using the cleaning chemicals specified for that product.
- When inappropriate cleaning chemicals are mixed with certain herbicides chemical reactions can produce harmful gases that are flammable or toxic.

Rainfastness

Rainfastness of herbicides varies, so refer to the herbicide label for these constraints. Rainfastness can be reduced if lantana is not actively growing, is under stress or is in conditions of low light.

- In general, it is suggested that foliar chemical application be avoided if rain is predicted within 4–6 hours. Basal bark applications are effective if bark is dry when applied even if wet soon after.
- Products containing fluroxypyr,[18] picloram[19] and triclopyr[17,19] are rainfast in one hour.
- Picloram in gel form (i.e. Vigilant® Gel) should not be used if rain is predicted within 12 hours.[69] When washed into the soil it can be absorbed by the roots of non-target plants.

Withholding periods

- Some herbicides will cause increases in foliage sugar levels, making lantana more palatable to stock after treatment. Therefore, do not allow stock to re-enter paddocks until treated poisonous plants have browned off and died down.
- Although some herbicides have a nil withholding period for stock animals, de-stocking areas for at least 7 days will allow effective herbicide uptake into the plant without disturbance.
- If using pasture for fodder, follow the label recommendations for time requirements before harvesting pasture, which can be up to 8 weeks.

Visible damage

- The visible damage to lantana caused by herbicides can be slow to appear, taking several weeks in some instances. Wilting, yellowing and dieback of the leaves occur first, advancing to complete browning of the above-ground growth and deterioration of the root systems.
- Most knockdown herbicides achieve complete brownout within 4–6 weeks and death in 9–12 weeks. However, full brownout may take 3–6 months for metsulfuron methyl.[22]
- In adverse conditions, the visible damage may be slower or herbicide application may only stunt or suppress lantana, requiring repetition of herbicide treatment during better seasonal conditions.
- Spraying early in the season after the first flush of growth may result in brownout of leaves and defoliation, but the resultant control may be low if the plant does not continue active growth. Spraying of new growth will be necessary the following season.

Regrowth after initial foliar spraying.

Herbicide resistance

All herbicides are at risk of being overused, leading to the targeted species building a resistance to the herbicide in question. Herbicides are allocated a herbicide group code according to the biology of the target plants and their response to the herbicide.

This determines the level of risk of the herbicide becoming ineffective. Most lantana herbicides have a low risk of this occurring. However, to avoid this problem, herbicides from different categories should be used from time to time.

Table 6: Herbicide resistance

Potential resistance level	Herbicide group	Mode of action	Active ingredients
High	A and B	**Targets specific plant cell processes** Individuals in the weed population may have cell processes varying from those targeted by herbicides in this group, making them resistant to the chosen herbicide. These varieties soon thrive to form an infestation uncontrolled by the original herbicide.	metsulfuron methyl
Moderate	C to H	**Targets general plant cell processes** Plants with resistance to these herbicides are less common. These herbicides can be used over a number of seasons with few problems of resistance; however, the possibility of resistance may occur.	
Low	I to M	**General or multiple modes of action** Due to the multiple modes of action, there is a smaller chance that weeds will be able to resist each action the herbicide takes, making resistance less likely to occur—though still not impossible.	glyphosate, picloram, triclopyr, dichlorprop, fluroxypyr, 2,4-D amine, 2,4-D n-butyl ester, aminopyralid

For further information on registered herbicides see the manual *Using herbicides on lantana* in the attached CD. Further information on recommended spray seasons and tools for calculating herbicide mix rates are provided in Appendix 2a to 2c.

Mechanical control methods

Mechanical methods are usually most suitable for the control of extensive lantana infestations. These methods reduce the bulk of thickets to allow access for other control treatments, and can be used to remove large mature plants that do not respond to other management techniques.

On the less positive side, mechanical removal of lantana with heavy machinery such as tractors and dozers may cause high levels of disturbance to the soil and desirable vegetation, increase soil compaction and can potentially increase rates of germination of lantana and other invasive weeds. It can also contribute significantly to soil erosion if used in sloped areas.

> Any land manager considering mechanical control of lantana should seek advice from their local council and state government to ensure land clearing and vegetation laws are adhered to.

Revegetation with pasture or regeneration of native vegetation should be carried out as soon as possible to protect disturbed soil and provide beneficial competition.[9] Follow-up treatment of lantana shoots/regrowth and seedlings with methods such as hand pulling or spot-spraying is essential. After pushing or stick raking, reshooting of lantana from broken stems or root stock is also likely, and requires follow-up treatment.

> It is important when mechanically treating lantana to minimise soil disturbance to prevent the removal of native seedlings (in conservation areas) that are usually present in good number[63] and/or reduce clearing of pasture grasses that may already be present, reducing costs in re-establishing competition.

Excavator grubbing—Berry, New South Wales.

Pushing lantana—Glen Ruth, Queensland.

Bobcat grubbing—Nowra, New South Wales.

Slashing/mulching

Slashing involves cutting plants at the soil surface with blades or chains that spin parallel to the ground. It can reduce the height and density of the thickets to enable access and more economic use of herbicides. However, it will generally leave root systems intact, resulting in significant levels of regrowth from the base of the stems. Small tractor/slasher combinations allow for slashing to take place among vegetation, while large tractor/slasher combinations allow for clearing of large pasture areas.

Mulching involves cutting plants at the soil surface, usually with a flail rotor mechanism. Mulching units held on arms of excavators are another means of control in areas where conventional slashers may not work (e.g. roadside verges, banks).

Advantages	Disadvantages
Regular slashing/mulching of lantana can successfully contain or suppress (but not remove) infestations even in large areas.	Usually does not kill lantana, only aids in temporary control.
Relatively low cost.	Only useful on relatively flat ground with no rocks.
Can reduce the height and density of thickets to enable other treatments, such as foliar spraying of new growth.	Vehicle hygiene risks.
Weakens plants, making them susceptible to follow-up control.	Can increase fuel loads (only a problem if not intending follow-up burn of waste).
Can be used to prevent mature bushes from flowering and setting seed.	Difficult to use in hilly or wooded areas.
	Promotes other weed establishment.

Timing

- Can be done all year round.
- Adult plants should be slashed before they have a chance to seed as this will help reduce the seed bank.

Slashing lantana—Yarraman, Queensland.

After slashing—Albany, New South Wales.

Stick raking/pushing

This technique uses a tractor-mounted rake or blade to push lantana out of the ground. A stick rake attached to a dozer removes the majority of the stump and root system from the ground while minimising the loss of topsoil. The tines of the blade slip through the soil and collect root stumps as they travel.

A cutter bar attached to the stick rake will also remove underlying roots that the tines miss. It is important that all stick raking/pushing be followed immediately with pasture seeding or revegetation as soil disruption encourages increased germination of lantana and other weed species.[9]

Tyre-wheeled tractors using a blade can push small infestations. However, dozers are required for larger areas.

Rough ground will reduce the effectiveness of stick raking/pushing. Using slashing as a follow-up up (where safe to do so), will ensure all regrowth is clumped and uniform and is therefore easier to foliar spray.

Advantages	Disadvantages
Useful for clearing the biomass from medium to large areas of infestations relatively quickly.	Disturbance to soil.
Can reduce the costs of follow-up controls.	Vehicle hygiene risks from other weeds.
Can be cost-effective for extensive infestations.	Regrowth from stumps and/or seedlings may require extensive follow-up.
Can prevent further lantana seed bank increase if used prior to seeding.	Expensive for small infestations.
Reduces volume of herbicide required for follow-up management.	Wooded areas may be inaccessible.
	Steep areas may be to difficult.
	Can strip plants leaving spindly canes that are hard to spot-spray.
	Promotes other weed establishment.

Timing

- Can be done all year round.
- Adult plants should be treated before they have a chance to seed as this will help reduce the seed bank.
- Works best when soils are moist to minimise effort and maximise likelihood of removing whole plants.
- Works best when there is a higher chance of pasture re-establishment.

Mechanical grubbing

Mechanical grubbing removes entire lantana plants from the ground with an implement attached to a tractor, backhoe, excavator or even a bobcat. It is suitable for scattered to moderate infestations of mature lantana and works best when some soil moisture is present, making it easier to grub out whole plants.

Implements vary from standard excavators and bobcat buckets, to purpose-built forks.

In pasture situations, always keep a bag of seed on your bobcat as throwing a handful into the disturbed area where the plant was grubbed can increase grass competition for potential lantana seedlings and regrowth.

Advantages	Disadvantages
Complete removal of infestations.	Time consuming as each plant must be treated individually.
Relatively low soil disturbance compared with pushing or stick raking.	Vehicle hygiene risks.
Can prevent further lantana seed bank increases.	Difficult in very hilly areas.
Complete removal of root ball will ensure minimal regrowth.	Likely to promote seedling recruitment in vicinity of root stock.
Usually requires fewer follow up treatments than other control techniques.	Promotes other weed establishment.

Timing

- Can be done all year round.
- Adult plants should be grubbed before they have a chance to seed as this will help reduce the seed bank.
- Works best when soils are moist to minimise effort and maximise likelihood of removing whole plants.
- Works best when there is a higher chance of follow-up pasture establishment.

Using a bobcat—Yarraman, Queensland.

After bobcat grubbing—Yarraman, Queensland.

Chain pulling

Chain pulling is the removal of mature plants by pulling a chain between two dozers or tractors. Chain pulling is most suitable for large dense infestations over medium to large areas and where there is little or no desirable vegetation. The chain is usually pulled in both directions.

Advantages	Disadvantages
Clears areas quickly to prepare for secondary treatments (usually burning). Useful where landscape topography is unknown.	Vehicle hygiene risks. Requires further work to remove lantana. Only possible in open paddock situations where there are no vegetation management restrictions.

Timing

- Can be done all year round.
- Adult plants should be pulled before they have a chance to seed as this will help reduce the seed bank.
- Works best when soils are moist to minimise effort and maximise likelihood of removing whole plants.
- Best timed to allow the use of follow-up fire management.
- Works best when there is a higher chance of follow-up pasture establishment.

Ploughing

Offset disc ploughing to cut and turn over stumps and roots is suitable in relatively flat areas where there are no rocks and the topography of the landscape is known. Ploughing is a useful follow-up treatment in areas that can be cultivated. Further regrowth and germination of new seedlings may necessitate ploughing a second time, or the application of other follow-up controls.

Advantages	Disadvantages
Allows rapid treatment of large areas. Creates a good seed-bed for establishing pasture.	Disturbance may promote the germination of lantana and invasion by other weeds. Vehicle hygiene risks. Increased potential for soil erosion.

Timing

- Can be done all year round.
- Adult plants should be ploughed before they have a chance to seed as this will help reduce the seed bank.
- Works best when soils are moist to minimise effort and maximise likelihood of removing whole plants.
- Works best when there is a higher chance of follow-up pasture establishment.

Control by trampling and grazing

Competition from existing/sown grasses and scrambling legumes with subsequent trampling and grazing by livestock can reduce the size, height and density of a lantana infestation, allowing access for follow-up controls. This can be particularly useful in areas where access is difficult for humans and machinery. Livestock are used as a control method for lantana in two ways:

1 Lantana thickets can provide structure for twining tropical legumes. Cattle forcing their way through the thickets to graze these legumes create tracks and tunnels, opening up access for people to undertake control treatments such as foliar spraying, splatter gun or the cut stump.

2 Competitive shade-tolerant pasture grasses can also be sown into lantana thickets, encouraging stock to trample the weed.

Advantages	Disadvantages
Cattle create tracks and tunnels through thickets creating access points to carry out control treatments.	Grazing of lantana is not recommended as grazing animals, including sheep, cattle and horses, are extremely susceptible to lantana poisoning. Goats and camels are less susceptible but long-term consumption is known to be fatal for goats and information for camels is limited. Trampling and grazing alone will not control lantana and must be followed with other treatments such as foliar spraying or cut stump herbicide application. Trampling and manure may bring about the germination of lantana seed or other weeds. Feral cattle, goats and some other animals cause their own impacts to vegetation in national parks and therefore are not an option in these areas and should be removed if present.

Timing

- Can be done all year round.
- Works best when other vegetation is available for grazing to reduce the risk of lantana poisoning.

The risk of poisoning

Care should be taken when introducing new or young animals to an area where lantana is present. Ensure they have enough feed to prevent them from eating significant quantities of lantana. Animals should not be placed in areas of infestation during drought. Any animals showing signs of poisoning should be moved to an area free of lantana, kept in the shade and monitored. A vet should be called immediately as animals can deteriorate rapidly.

For information about the signs of lantana poisoning and its treatment, see Appendix 6—Lantana Poisoning.

Biological control

For nearly a century, biocontrol agents have been released to combat lantana.[77] In total, 31 biocontrols (30 insects and 1 rust) have been introduced. Eighteen have become established, and 4 of these, all insects, are effectively reducing the vigour and competitiveness of lantana in certain areas.[15]

Biocontrol seems to provide an alternative to active management. However, the impacts these agents have are seasonal and do not generally result in the death of the plants. Despite this, they offer the only current management option in some steep and inaccessible areas and can be integrated with other approaches.

The Lantana biocontrol table (in Appendix 7) lists biocontrols in order of their effectiveness, and the information sheets on the accompanying CD include distribution maps for each agent.

Biocontrols alone cannot eradicate lantana, but their presence can help to contain infestations, reduce their spread in the long term, and enhance the feasibility and effectiveness of other methods of control.

Advantages	Disadvantages
Can help to contain infestations.	Biocontrols alone cannot eradicate lantana.
Can reduce spread in the long term.	Variable results from different agents in different climates.
Can enhance the feasibility and effectiveness of other methods and reduce follow-up control costs.	Can be costly to process and release agents (because rigorous testing is required to ensure agent-host specificity and avoid off-target damage).
Only control option for inaccessible areas such as rocky gullies and steep slopes.	Defoliation caused by some agents restricts the use of fire and many herbicides.
Provides ongoing suppression on unmanaged/ abandoned lands.	
Allows light penetration, promoting grass growth.	

Timing
• Seasonal.

Community Biocontrol Program

The Community Biocontrol Program is currently coordinated under the Lantana Weeds of National Significance Program. This program trains members of local community groups to coordinate the release of biological control agents in strategic sites and, most important, to monitor their presence and impacts. Councils, state agencies and community groups from Queensland and New South Wales have participated so far.

Control by fire

Control of lantana using fire is widely practised as a cost-effective means of biomass removal and lantana suppression. In pastoral situations, it requires locking up infested paddock for long enough to accumulate sufficient fuel or dozing windrows/fire breaks, to carry/control a fire/burn. However, the use of planned burning implemented at inappropriate times or under inappropriate conditions may lead to an exacerbation of lantana in the landscape.

A complex array of variables have an influence on fire management success, including: time of year, climatic conditions (such as wind, temperature, soil moisture and humidity), the quality and types of fuel loads, the speed and intensity of the fire, fire regime and the timing of stock reintroduction.[67]

> Some general guides are provided in this manual but local knowledge will be the best guide and it is suggested you talk with local community members who have learnt the best approach by experience gained over many years.

Burning will also depend on obtaining a suitable fire permit and the establishment of fire breaks to prevent damage to non-target areas and neighbouring properties. These elements, as well as the possible loss of production where paddocks require spelling before and after management, can add considerably to the cost of using this technique and should be considered during the planning process. Managing fuel loads prior to burning, and ensuring well timed follow-up control and good pasture regeneration, is critical when using fire in an integrated lantana control plan.

Advantages	Disadvantages
Relatively inexpensive. Encourages local flora regeneration (in natural ecosystems). Promotes pasture regrowth. Good for clearing large areas of infestations relatively quickly to reduce biomass and provide access for follow-up control. Pasture seed can be sown directly into the ash bed.	Destruction of desirable vegetation or pastures through inappropriate fire regimes. Threat to the safety of humans, domestic and native animals. Potential destruction of property. Can expose soil, leading to erosion. Can be costly if establishment of fire breaks and spelling of pasture to control fire are involved. Too frequent fire events can cause damage even to fire adapted ecosystems. Inappropriate for fire-sensitive ecosystems (e.g. rainforests). Season and weather limited. Permits may restrict timing of burn.

Timing

- Can only be used when burning permits are available.
- Works best when there is a higher chance of follow-up pasture establishment.

How does fire affect lantana?

Regular planned burning can help to reduce the height and density of infestations,[57] and create better access for further control. Fire management must be followed with other control methods as it tends to suppress rather than kill the plants. Even after high-intensity fires, lantana will recover quickly (unless drought-stressed), reshooting from the base of burnt stems.[57] Marginal results are achieved using fire as a sole control technique.

Planned burning

Planned burning contains fire to desired areas and prevents unwanted damage. Risk is minimised by:

- using firebreaks and back-burning techniques to contain fire
- managing fuel loads
- avoiding unfavourable climatic conditions (after long dry periods, during high winds especially from W–NW–NNW, or under low relative humidity conditions).

In all situations, seek expert input for the planning and implementation of fire control programs.

Preparing for a planned burn

- Obtain a permit from the relevant fire authority. These are mandatory, and usually set out further requirements for personnel and equipment as well as for actions such as notifying neighbours and posting signs on roadways. Also, some state agencies require a fire plan to be prepared.
- Check weather forecasts for information about wind speed and direction, temperature, humidity and rain.
- Check the locations of firebreaks and ensure fuel loads in these areas are low. Reduce fuel loads by winter burning or mechanical clearing.
- Ensure the availability of water, fire-fighting equipment and personnel.
- Draw up a plan for emergency situations and a list of contacts if extra help becomes necessary.
- Before lighting, call your fire authority to inform them you are conducting a burn and cite your permit number or reference.
- Always perform a test burn, watch and decide whether to proceed.

Fire breaks need to be created to ensure desirable vegetation or infrastructure is not damaged.

Conditions and fuel loads

- Ideal weather conditions for burning are low wind speed (CSIRO fire research suggests no lighting with winds above 24 km/hr) and moderately low humidity for several hours before burning. Ensure weather forecasts do not predict changes in the conditions.
- Low-intensity fires are produced when temperatures are cooler in the late winter and spring, and it is best to burn after rainfall events when soil moisture levels are high. Summer burning is possible if there has been sufficient rainfall (25+ mm). However, this will depend on permit approval from local fire authorities.
- Green lantana will burn readily[30] but a greater fuel load will be necessary to carry fires of the same intensity. Younger lantana infestations carry more leaf matter than mature ones, and will burn at a higher intensity.
- Fuel loads are usually drier and will burn more readily on northern and western slopes than on southern and eastern slopes.

Fire in natural ecosystems

While the effect of fire on different natural ecosystems is reasonably well known, some aspects of the use of fire for controlling weeds (such as the optimum timing and burn intensity) are still being researched. As natural ecosystems have evolved particular tolerances and dependencies on fire, its use for the control of weeds has to be managed to avoid damaging more fire-sensitive or non-fire-adapted vegetation. The use of fire to control lantana in natural ecosystems should be integrated with fire management plans for the area.

Lantana appears to play an important role in forest margin fire ecology[35,67] as,under certain conditions, even green lantana burns readily.[30] Lantana occurs abundantly on rainforest margins and due to the woody nature of the lantana thickets, tends to draw the fire into dry rainforest,[49,67] causing significant damage to some of our rarest ecosystems. In hotter, drier and windier conditions, where lantana will burn fiercely, its presence can cause severe damage to the rainforest edge.[74]

The presence of lantana dramatically alters, and increases, the fuel characteristics and flammability of fire-sensitive dry rainforest.[21,24,25] Increased litter load from lantana also encourages prolonged burning. After a fire has occurred, lantana will regrow from dormant basal buds.[67]

Low-intensity hazard-reduction burning.

After-effects of a low-intensity burn.

Fire has also been reported to promote the spread and density of a number of other exotic plant species,[1,11,13,46,72] usually by reducing plant competition and increasing the soil fertility. Therefore, weed management using fire must be integrated with other control techniques. For example, this use of prescribed burning and herbicide in a wet sclerophyll forest of South-East Queensland was found to be a suitable method for both lantana control, natural regeneration and the protection of native reptiles.[75]

For conservation, site managers and landholders will need to consider management techniques to limit off-target damage to environmental assets.[47] Each management technique must be tailored to the environmental asset at each site and as such landscape scale control measures, such as fire, may not be appropriate for the protection of high priority assets such as endangered or vulnerable species or ecosystems.

Frequency, extent, intensity and season

Each of these factors should be considered when drawing up a strategy for controlling lantana in natural ecosystems with fire.

Frequency

Fire-adapted plant species can decline in number or even become locally extinct as a result of burning that is either too frequent or too infrequent. The intervals between burning are crucial to managing fire for biodiversity in natural ecosystems.

- Wet sclerophyll forests need high-intensity fires at intervals ranging from 20 to more than 100 years. Less intense understorey fires may also help the regeneration of these forests, at intervals of at least 6 years for grassy understoreys and 12 years for shrubby understoreys.
- The appropriate frequency for fire in dry sclerophyll forests, open eucalypt forests and woodlands is dependent on the nature of the understorey. Grassy understoreys are often maintained by burns at short intervals (between 3 and 6 years), and shrubby understoreys by intervals of between 7 and 25 years.

An example of patch burning—Tallawalah, Queensland.

Extent

A patch burning, or mosaic, approach is desirable for all natural ecosystems. The unburnt patches serve as a source of seed for plant regeneration, and provide animals with shelter and a food source for immediately after the fire, as well as a base from which to recolonise burnt areas as they regenerate. Adjacent patches should not be burned for at least 1–2 years. Patch burning also helps to break up fuel loads and slow wildfires.

Intensity

Although higher intensity fires are generally more destructive, they can be necessary to break the seed dormancy of some native species, or for more effective control of woody weeds such as lantana. Intensity will depend not only on season, but also the length of time since the last burn. In general, fires will become less intense the more often an area is burnt, as shorter intervals allow less time for fuel loads to build up. Managers should consider varying the intensity of planned burns to mimic naturally occurring variation.

Season

Research shows that different plant species within the same ecosystem are favoured by fires at different times of the year. Varying the season of fires between late summer, autumn and winter would therefore be appropriate.

Fire in pasture situations

Frequency, extent, intensity and season
(adapted from Hunt 1996)

Frequency

For native pastures in good condition, an appropriate interval between fires is 3 to 6 years, with more frequent burning if woody weeds such as lantana or rank grass need to be cleared. Burning every paddock annually is usually undesirable. Too frequent burning can lead to erosion, reduce desirable pasture species, and lower carrying capacities.

Extent

The proportion of a property burnt in any one year will depend on the available fodder (including reserves of drought fodder), the level of wildfire hazard, the nutritional quality of paddocks, the extent of infestation of woody weeds, and the amount of land able to be rested after a fire. Fires should cover whole paddocks, as patch burning can lead to uneven grazing pressure in paddocks and overgrazing of new grass shoots in the burnt areas.

Burnt lantana in pastures.

Intensity

High-intensity fires are not recommended as they can kill or severely retard pastures. After such a fire, re-sowing pasture grasses will usually be necessary. Fire can also damage soil. Exposed soil is susceptible to erosion by wind and water, and small amounts of the nutrients nitrogen and phosphorous are lost to the atmosphere during burning.

High-intensity burning in one area for too long can cause an excessive loss of nutrients and kill microbial agents. Fast-moving fires will cause the least damage.

Season

Fire control in Queensland has traditionally occurred in June–August, before seasonally high winds and dry air become a factor. However, in south-east Queensland, burning in late spring to early summer—when lantana is actively growing—has proven more successful than burning in winter.

The risk of erosion is lowered by burning in October to November, when soil moisture is available for new pasture growth. In tropical and subtropical areas, there is anecdotal evidence to suggest that intense burns in late summer following rains, and where adequate soil moisture is present, are likely to provide a better kill-rate.

In New South Wales, where temperate rains occur during autumn and winter, fire is most appropriate during the winter months.

Section 4

Decision Support Tool

The Decision Support Tool

The Lantana Decision Support Tool is a computer-based system to help guide land managers through the complex task of integrating control techniques to provide an efficient and cost-effective solution to their lantana management problems.

Information for the development of this tool was drawn from 3 years of adaptive management field trials at 11 sites throughout the distribution of lantana in Australia.

1 The land manager is required to answer a series of questions concerning the key variables as they relate to the targeted management site. These variables include:

- access to infestation
- density of infestation
- size of infestation.

Guiding definitions, including pictorial representations, are provided as part of the tool to ensure accurate information is provided.

2 The answers to these questions lead the land manager to a selection of available management sequences and information on how to implement them. This will include information on:

- the estimated time per area required to undertake the management action
- the estimated cost incurred per area
- the expected efficacy of controls
- the overall timeline to achieve control and/or implement the sequence
- limitations and suitability of the techniques used.

From this information, the land manager can determine which control sequence is most appropriate to their situation on the basis of expected management outcomes, available equipment, labour requirement and funding and the time restrictions for completion of the control activity.

Support information is provided in the associated sections of this *Lantana Best Practice Manual* and should be read prior to undertaking management activities.

Information on key variables

In order to get the best from the Decision Support Tool you will need to have completed a Property Pest Management Plan (or a Site-Specific Management Plan under the Plan to Protect Environmental Assets from Lantana), part of which involves mapping areas of lantana on your property (for further information refer to Section 2 on Property Pest Management Planning). Once mapped, you will need to assess each lantana infestation area separately to provide information on the key variables that drive the Decision Support Tool.

Please answer the following questions:

- What are the land management outcomes required (i.e. production or conservation management)? (Please note, conservation goals can be identified for selected areas of a primary production property).
- What is the area of the selected management site?
- What is the density of lantana at this site?
- How accessible is the site and the lantana you have chosen to manage?

The key variables: access, density and size

To simplify the Decision Support Tool while maintaining its value, several key variables were chosen to guide landholders to potential control sequences. These variables (defined below) influence the type of management options available, the cost of control and the likelihood of successful lantana management.

Access

Access to infestations will greatly affect the types of control available. Access can be influenced by the localised terrain at the site of the infestation and by the ability to transport vehicles or equipment to the site. In addition, there may be an increased danger during mechanical controls if there is limited knowledge of what lies underneath dense lantana infestations (e.g. rocks or gullies). All three elements should be considered in your assessment of access.

For the purpose of the Decision Support Tool, access to an infestation is categorised as:

a. *easy*—can easily transport personnel and machinery to the lantana and operate the machinery on site (e.g. open paddock, flat, no obstacles to transverse on way to site)

b. *moderate*—can easily transport personnel but only limited machinery to the lantana (e.g. open woodland over a creek)

c. *difficult*—can transport personnel but not machinery to control the infestation (e.g. forested slope, river, considerable obstacles to transverse on way to site).

Table 7: Access to an infestation

Machinery/personnel	Access category		
	Easy	Moderate	Difficult
On foot	Yes	Yes	Yes
Trail bike	Yes	Yes	Yes
Quad bike	Yes	Yes	Yes
Conventional vehicle (with spray unit)	Yes	Yes	No
Bobcat	Yes	Yes	No
Small tractor, excavator or bulldozer	Yes	No	No
Large tractor, excavator or bulldozer	Yes	No	No

Density

Density can strongly influence the types of control methods recommended, mainly due to access of control options and the variable effectiveness of different control strategies for the management of high or low densities of lantana. In broad terms, density can be linked to control strategy thresholds (adapted from McNaught et al 2008):

- 1–15% cover—control by promoting competition and spot-spraying
- 15–50% cover—control by promoting competition, broadacre chemical control and some mechanical
- › 50% cover—requires broadacre treatment, pasture establishment and spot-spraying regrowth.

Density definitions and examples

For the purposes of the Decision Support Tool, the density of a lantana infestation is categorised as:

a. light density

- plants are sporadic with grass areas between them
- ‹ 500 plants per hectare
- ‹ 10% cover (WoNS mapping Class 3) [45]
- usually less than 1 m high
- often composed of new seedlings and fresh regrowth
- access available to individual bushes.

b. medium density

- lantana forming clumps with some grass areas
- 500–2500 plants per hectare
- 10–50% cover (WoNS mapping Class 4) [45]
- approximately 1–2 m high
- small to large bushes
- access diminished to vehicles but not to humans.

c. high density

- lantana is generally impenetrable without cutting access trails
- › 2500 plants per hectare
- usually › 2 m high
- ‘old man’ lantana common
- › 50% cover (WoNS mapping Class 5) [45]
- access denied except through initial mechanical or fire treatments.

Size of infestation

The size of an infestation also has a significant impact on the type of control methods that are applicable. For instance, large scale equipment and/or aerial management options are unlikely to be available, or economically feasible, for use on a small infestation. Conversely, manual removal methods are uneconomical on a large scale. Significant saving on costs due to economy of scale principles can be achieved by tackling larger infestations and reducing the fixed costs of using equipment or contractors.

For the purposes of the Decision Support Tool, the size of a lantana infestation is categorised as:

a.	local infestation	i.e. ‹ 0.25 ha in area	~ small outbreak (50 m × 50 m)
b.	small infestation	i.e. 0.25–1 ha	~ small section (up to 100 m × 100 m)
c.	medium infestation	i.e. 1–10 ha	~ small/medium paddock (up to 1000 m × 100 m)
d.	large infestation	i.e. 10–25 ha	~ large paddocks (up to 1000 m × 250 m)
e.	very large infestation	i.e. › 25 ha	~ several paddocks (› 1000 m × 250 m)

These categories have been determined as the cut-off points where different control strategies apply.

Now armed with this information you are ready to use the Lantana Decision Support Tool. Please see the accompanying CD at the back of this manual.

Incorporating fire and biocontrol into your management plans

Fire and biocontrol are not given as first options in the integrated management sequences provided by this Lantana Decision Support Tool as they are highly variable in both costs and results. This does not imply they are not useful integrated management options.

If you intend to use fire or biocontrol as a first management option, it is recommended you assess each patch and use this as your starting to point. Each patch can then be run thorough the Decision Support Tool to provide suggested sequences for managing your lantana from this point on.

Further information

Frequently asked questions

Herbicide FAQs

Selective and residual herbicides

Q. Does a selective herbicide only kill lantana?

A. No. Selective herbicides (e.g. Grazon® Extra, Brush-Off®, Lantana 600) will kill lantana and certain other plant species while leaving some desired plants, such as pasture, undamaged. Non-selective herbicides (e.g. Roundup®) affect most plants they come in contact with. Information on selectivity is provided on the herbicide label; however, the list of species affected by the herbicide will not be exhaustive and care should always be taken. For further information contact the relevant herbicide company representative.

Q. What does a residual herbicide do?

A. Residual herbicides (e.g. Grazon® Extra) are designed to remain active in the soil, keeping treated areas lantana free for up to twelve months. It is important to note that follow-up control is still required, as the residual effect alone will not completely suppress or kill treated plants/areas.

Spray timing

Q. Sometimes I spray lantana regrowth or new seedlings as soon I see them. Is this the correct approach?

A. No. Although some people spot-spray regrowth as soon as they see a few leaves this is the wrong thing to do. Regrowth after burning, cutting, slashing, dozing or frost is best treated with foliar spraying when it reaches a height between 300 mm and 1 m. If you spray too early there will not be sufficient foliage (leaf area) to actively translocate enough herbicide to the roots and little control will be achieved.

Q. When is the best time to spray 'old man' (mature) lantana?

A. Mature lantana is best treated by foliar spraying between February and the first frosts (i.e. after the growth of the wet season). Many herbicide labels suggest higher rates for plants above 1 m in height, so it is advisable to read the label before spraying. In many instances mechanical control is a better first option, especially for plants greater than 2 m.

Q. I know I should spray lantana when it is actively growing but can I still spray it as long as it is flowering?

A. Yes. Flowering is a clear sign the plant is actively growing. Nevertheless, better results are usually achieved in late summer, early autumn (see Appendix 2a).

Q. What is the best way to check the plant is actually dead?

A. Check by snapping the stem close to the ground to see if there is any moisture present. If there is not, presume the plant is dead. Cattle will generally be able to push dead lantana plants out of the ground about nine months after herbicide application.

Q. It is recommended that most herbicide be applied when the plant is actively growing. Is this the case for basal bark and cut-stump applications?

A. Although all herbicide treatment is best done when the plant is actively growing, these application techniques can be used on defoliated plants, as foliage is not required for herbicide uptake. This can extend the treatment period into the drier months of the year.

Spray techniques

Q. What happens if I spray too much herbicide mix; that is, beyond the initial point of run-off?

A. Depending on the herbicide used, this can put the plant into shock and reduce the chance of herbicide absorption and, therefore, the kill rate.

In addition, excessive use of herbicide (even selective herbicides) can kill grass in the area surrounding the target plant, decreasing pasture competition and potentially causing increased establishment of other weeds.

Q. Do I need a permit or licence to spray lantana?

A. In most cases you do not need a permit; however, there are exceptions and it is recommended you check the herbicide label or consult with your local authority to be certain.

If you are contracted to spray or are spraying on somebody else's property, then you do need a licence.

- In Queensland, a 'commercial operator's licence' is required under the *Agricultural Chemicals Distribution Control Act 1966* and these are issued by the Department of Employment, Economic Development and Innovation. It is also important to take note of the Agricultural Chemicals Distribution Control Regulation 1988 (ACDC Regulation).
- In New South Wales, the *Pesticides Act 1999* requires all commercial operators to be trained in pesticide application, with a minimum of an AQF2 unit of competency (applying chemicals under supervision).
- For working near threatened species or ecological communities in New South Wales, a Section 132C licence is required (see www.environment.nsw.gov.au/lantanaplan/implementation.htm).
- For other states please check with your local authority.

Aerial spraying

Q. How much does aerial spraying of lantana cost and how long does it take to spray a certain area?

A. The only registered method for aerial spraying lantana is via helicopter. Hourly rates for helicopter contractors range from $1000–$1500/hour depending on location and size of machine. Depending on the size of the job, some contractors also charge ferrying costs (cost of flying to and from the job).

Using the best practice method of a 200 L/ha solution mix and the half-over-pass method, a helicopter can expect to cover 3–6 ha in one hour. The approximate cost of herbicide required to cover:

- 3 ha would range from ~$300 (Lantana 600 @ 8 L/ha i.e. 24 L) to ~$1100 (Grazon® Extra @ 10 L/ha, i.e. 30 L)
- 6 ha would range from ~$600 (Lantana 600 @ 8 L/ha i.e. 48 L) to ~$2200 (Grazon® Extra @ 10 L/ha, i.e. 60 L)

Therefore aerial spraying costs, including chemical, would be approximately:

- $1300 and $3750 per hour *or*
- $400 and $600 per hectare.

Splatter guns

Q. I have heard of the splatter gun being used by national parks but can I use it in agricultural situations?

A. Absolutely. The splatter gun works very well in all situations as long as the lantana is bushy/compact. The splatter gun can be used effectively on anything from isolated plants to dense infestations and is a cheaper option than purchasing and using high volume spray equipment.

Q. Is the splatter gun easy to use?

A. Yes. The splatter gun is quite efficient and easy for an individual operator to use. The actual technique is as easy as shooting a water pistol. There are manual or gas powered options available commercially. Some operators find that using the manual splatter gun is tiring because of the additional force required to pump the fluid through the gun. Comparatively, the gas-powered option only requires the use of a finger to release the herbicide mixture. The additional costs of gas and maintaining the regulator should be considered.

According to John Hunter (Department of Environment and Climate Change, New South Wales), 'To get the maximum range, incline the gun at a 45 degree angle and squeeze out a continuous stream as you smoothly bring the gun to the horizontal position. This gives a line of 9:1 (9 parts water: 1 part glyphosate 360 g/L) across 15 metres or more of the thicket'.

Q. Does the splatter gun method really control lantana?

A. Most definitely. Research trials from North Queensland to south coast New South Wales show it works well in both forested and open situations. Less follow-up control is required on pink lantana than other flower forms, but with a small amount of follow-up great results can still be achieved.

According to Susan Somerville, an experienced splatter gun user from northern New South Wales, 'It is very successful in forested areas with some canopy already in place. We are getting good regeneration of native vegetation and very little lantana reinfestation from seed. Those areas in the forest treated one to two years ago are stable and regenerating nicely. Open areas of lantana where the lantana gets full sun and does not have much native vegetation to compete with it, tends to recolonise and requires follow-up'.

Spray volumes and mixes

Q. People in my area talk about a 'special brew' of herbicides they mix together to spray. Can all herbicides be mixed together?

A. No, only some of the herbicides registered for lantana control are compatible. Mixing non-compatible herbicides can result in reduced control and can effect spray equipment by causing excess foaming, increasing precipitates in the tank, and clogging spray nozzles.

It is important to take note of the information on each label when mixing herbicides. In general the order to mix any herbicides is:

1. wettable powders or dry flow formulations (e.g. Brush-Off®)
2. suspension concentrates (flowables)
3. water soluble salts (e.g. Tordon® 75-D, Amicide® 625)
4. emulsifiable concentrates (e.g. Starane® Advanced)
5. if required, add surfactants and penetrants last to minimise foaming.

Read and follow all label directions, restraints, plant-back periods, withholding periods and safety directions for the tank mix products.

Q. What herbicides that are registered for lantana can be used on other associated weeds?

A. Many herbicides registered for lantana can be used to treat other weeds simultaneously (see Appendix 2d), thus achieving greater efficiency in your spray operations. In this instance it is important to balance overall efficacy, time investment, cost of the product and range of plants controlled when choosing which herbicide to use. Please ensure you read the labels carefully as rates for other weeds may differ.

Q. What does brown-out indicate in terms of plant health and does a quicker brown-out mean a better kill rate?

A. Brown-out (or brown-off) refers to the wilting and yellowing of plant foliage. Brown-out does not necessarily indicate plant death but does mean the plant is being affected by the herbicide. It can be used to identify any missed spray areas.

A quick brown-out does not necessarily mean a greater kill rate. Herbicides have variable rates of brown-out. However, a quick brown-out can sometimes be a symptom of a herbicide rate that is too high, which can cause a stress response and quick defoliation before translocation of the herbicide is complete. Often a slower brown-out implies a slower and more complete progression of herbicide through the plant and a better chance of control.

Once brown-out and leaf drop has occurred, trampling by cattle can be an effective means of reducing the biomass of canes and opening up the country for good fodder growth. If sufficient fuel loads are present, fire can also be an effective tool follow-up technique.

Off-target damage

Q. How do I prevent pasture and native plants being affected by herbicide?

A. Spray drift from some herbicides will cause off-target damage. Read the herbicide label to ensure the use is appropriate and reduce off-target damage by careful application to protect desirable plants, crops, cropping land, pasture legumes or native vegetation.

- Still days with no wind are not ideal, as spray drift cannot be predicted. Wind conditions of up to 15 km/hr are preferable.
- Avoid draining or flushing equipment near native or non-target plants or in locations where the chemical may be washed or moved into contact with their roots.
- Exercise caution when spraying near water systems as some herbicides are toxic to aquatic animals. Herbicide labels recommend not spraying over water bodies and provide guidelines to spraying distances from any portable water source—either still reservoirs or flowing creeks.
- Roundup® Biactive™ is specifically developed for use in aquatic situations, but adding a surfactant will negate its environmental suitability unless specified on the label.[52]
- On contact with soil, glyphosate tightly binds to soil particles,[61] becomes inactive and will have no residual effect.
- When treating plants adjacent to desirable species, cut, scrape and paint or cut stump applications may be a preferable option.

Withholding periods

Q. When can I let my stock animals back into an area sprayed by herbicide?

A. As some herbicides will make lantana more palatable to stock after treatment [20,50] it is a general rule that stock should not be allowed to re-enter paddocks until treated plants have died back. In addition, some herbicides have withholding periods detailed on their labels. Stock should not be allowed back in to sprayed areas until after these withholding periods.

Q. What does the term 'withholding period' mean on a herbicide label?

A. A withholding period is the time required between the last application of a herbicide and the harvesting, grazing or slaughtering of beasts from within the treated area. Although some herbicides have a nil withholding period for stock, the advantage of de-stocking areas prior to treatment is that it allows herbicide uptake into the plants for at least seven days without disturbance.[22] If using pasture for fodder, follow the label recommendations regarding time requirements before harvesting pasture. This can be up to eight weeks when using Tordon® 75-D.

Manual control FAQs

Q. Is there a best time of year to clear lantana or can I do it any time?

A. You can clear your lantana anytime of year. However to maximise chances of removing lantana and producing a good seed bed for improve pastures, clearing when soil moisture is present is best. Avoid clearing your lantana until you are ready to improve pastures/regenerate native vegetation, as clearing lantana without planting, or at least the presence of competitive plants, may result in an increase in other weeds as well as the strong return of lantana.

Q. Can I clear other vegetation at the same time as clearing my lantana?

A. There is no simple answer to this question. Land managers should consult their relevant local government and state agencies before conducting any lantana management to ensure they comply with all relevant state legislation and local by-laws.

Examples:

- In Queensland, the *Vegetation Management Act 1999* (Queensland) stipulates that a permit is not required to clear non-native vegetation, including declared weeds. However, it is noted that it is an offence to clear or destroy remnant vegetation without a permit (whether by ring barking, cutting down, pushing over, burning or flooding), including destroying native plants while undertaking control of non-native species.
- In New South Wales, contact the Department of Environment and Climate Change before undertaking any mechanical control, particularly along creeks or on steep slopes.
- In New South Wales, many local governments also have environmental by-laws pertaining to what control is allowed in certain areas. An application for physical removal of the lantana may be required, but often foliar spraying and other non-destructive techniques will be fine.

For example, the Shoalhaven City Council Environmental Protection Zoning criteria stipulates physically removing lantana may require a Development Application to be submitted outlining control methods to be used and waste and soil management plans.

Always check your local and state government laws before beginning a lantana control plan, especially involving any mechanical control!

Machinery

Q. Will repetitive slashing ultimately kill my lantana?

A. Yes and No. The results of a twice annual slashing program (early spring, late summer) at Yarraman in South-east Queensland on a medium density 2 ha area of lantana showed that after three years lantana density had only been reduced from 60 to 50%.

Slashing is effective for opening up dense stands of lantana and, provided follow-up control by other techniques is undertaken, lantana can be effectively controlled. Slashing by itself will not generally kill lantana—it will merely suppress its growth.

Slashing is more often used as a maintenance method. It can reduce the spread of lantana and reduce the seed bank (if slashed before flowering). However, to successfully remove lantana follow-up spraying will be required when regrowth has reached at least 300 mm. An integrated program like this can result in quick clearing of low to medium density infestations (within two years in some cases).

Q. Many bobcats come with different attachments for grubbing—for example buckets, combo-buckets or forks. Does it matter which I use to grub lantana?

A. There is a difference between normal buckets and forks. Forks allow for more accurate removal of individual plants in low to moderate density lantana, with less soil disturbance than buckets. However, buckets and combo-buckets can be more useful when dealing with high density lantana where individual plants are hard to distinguish. Therefore, the plant density and situation will determine which option will be best for you.

Revegetation/regeneration FAQs

Q. Can I cut the bulk of the lantana away, then re-cut the stems for cut stump herbicide application or does it all have to be done in one go?

A. If it is difficult to access the base of the lantana plants for cut stump or basal bark herbicide application, the lantana plants can be 'pruned' to create pathways. For cut stump herbicide application, the final cut must be made close to the ground and the herbicide applied within 15 seconds to ensure the wound does not seal before the herbicide penetrates.

Q. After controlling lantana in a conservation situation, should I replant with natives or allow natural regeneration to take place?

A. Again there is no single answer but in general it is best to follow the 'three Rs' of bushcare as prescribed by the Australian Association of Bush Regenerators (AABR) and they are:

- first r**etain**

  … all the patches of native vegetation we still have. We are not able to recreate bush once it is gone—it is far too complex. Even tiny patches are important and protecting them is the priority.

- then **regenerate**

  … whenever we can. Damaged bush can recover with the right assistance. Even cleared or mown areas can sometimes regenerate if the original soil profile is intact. Natural regeneration preserves the unique character of each patch of bush and offers the best chance for a degraded area to become a balanced eco-system that needs minimal maintenance.

- finally **replant**

  … only where there is no bush and no potential for it to naturally regenerate (often where long-term disturbance has occurred). Planting is often seen as a quick and easy way to restore the bush. Nevertheless, it can damage a bush remnant by changing its species composition and genetic make up, and undermine its ability to ever recover naturally. Planted areas require more continuing attention than real bush and do not recover well from natural disturbances such as fire.

(The above text was taken from the AABR's poster 'The three Rs of bush regeneration')

For further detail, see Figure 3.2 of the Plan to Protect Environmental Assets from Lantana.[47] This matrix helps land managers determine if additional restoration activities, such as replanting, are required for a site.

Q. When clearing lantana should I cut it down for mulch or take it off-site?

A. It is usually best to leave the lantana bulk on-site if it does not obstruct other management activities. Lantana breaks down quickly, with the benefit that resources taken by the lantana plant are returned to the soil.

Plants can either be cut into small pieces as mulch, or the structure left intact to act as cover and shade for emerging plants (preferably native). It can also provide short-term habitat for native animals, provide protection from feral predators, and act as a deterrent to hungry wallabies!

If mulching lantana, it is vital that you monitor for regrowth as lantana readily shoots from nodes in the stems. Care must be taken to ensure pieces are not trodden into the ground—this effectively 'plants' the stems and increases the chance of regrowth.

Uprooted plants should be turned on their crowns so roots are not given the chance to reshoot.

Biocontrol FAQs

Q. If biocontrol agents are attacking my lantana, what should I do next?

A. There are 18 biocontrol agents established in Australia that aid in the control of lantana through suppression of spread. However, none of these will cause the complete control of lantana infestations without integration of other management techniques.

Some landholders mistakenly believe biocontrol agents are incompatible with other control methods or that the presence of biocontrol agents alone makes further control unnecessary. However, active management *should* be continued in the presence of biocontrol agents to capitalise on the control they have already provided. Concerns about the impacts of control techniques on the agents themselves are unfounded as populations will recolonise from adjacent areas in the following seasons.

Extensive leaf damage and leaf drop caused by biocontrol agents can limit control options as foliar spraying will be less effective. However, recent limited trial work in South-east Queensland has shown Fluroxypyr (e.g. Starane®), used at registered foliar spray rates, is effective on plants that have been partially defoliated by *Teleonemia scrupulosa*, a leaf sucking bug. Starane® has also been shown to be effective on stressed plants.[41] More research is needed for other herbicides, locations and flower forms.

In many instances mechanical or manual control methods, or basal bark and cut stump herbicide application are more suitable. Control by fire is another possibility, as long as fuel loads are adequate. In these instances, the benefit of biocontrols is that the plants are under stress when active management techniques are used so levels of regrowth are likely to be less.

Q. How can I tell if biocontrol agents are present?

A. Look for beetles or bugs on the tops of leaves, bugs or larvae underneath the leaves, or insects in the flowers or on the fruit or stems. Sometimes the agents themselves are difficult to see and only the damage they cause to leaves or flowers will be evident. The biocontrol fact sheets provided in the attached CD provide images of the insects and the damage they cause. Biocontrol agents act seasonally, so although they may cause significant damage at certain times of the year, at other times they may be low in number and cause no apparent damage.

Q. Do I need to spread the agents around?

A. This a matter for debate. Many lantana biocontrol agents have been established in Australia for more than 30 years and the most effective and proven biocontrol agents have already spread throughout areas to which they are suited, following their host plant and preferred conditions. In most instances it is suggested that landholders do not need to collect insects and relocate them to their property as they will recolonise through natural processes if the area is suitable. There may be benefits in community-based rearing and distribution of new biocontrol agents that have not yet reached their full distribution.

New agents are being researched by Biosecurity Queensland. In partnership with community groups and local government authorities, Biosecurity Queensland and the New South Wales Department of Primary Industries release new agents in areas where they are likely to survive and establish.

Q. Do I need to keep some lantana for the biocontrol agents to live on?

A. No. If it is possible to remove all the lantana and carry out proper follow-up and revegetation, there is no reason to leave part of the infestation for the sake of biocontrols. Where incomplete control is achieved, biocontrol agents will re-colonise from adjacent areas.

Camels and goats FAQs

Q. I have heard of people using camels and goats to control lantana. Are the animals affected by the lantana toxins?

A. Goats and camels are sometimes used for weed control. Nonetheless, caution is advised as outside of Australia there have been deaths attributed to lantana poisoning for goats.[7,38]

Information about the toxicity of lantana on camels is inconclusive at this stage. Some Queensland Government testing indicated there was no evidence of toxicity from lantana, but this did not explore the long-term effects and results were likely reduced because of the low-toxicity form of pink lantana on which the camels were feeding.

Land managers using goats and camels for grazing lantana should monitor for any poisoning effects over time. It should also be noted that camels and goats are considered feral animals in many places, are not a suitable means of lantana control in conservation areas and must be contained on private properties.

Appendix 1 Example map and data record for Decision Support Tool

To effectively use the Lantana Decision Support Tool a map is needed similar to the one shown below. The map outlines each infestation with details of its access, density and size.

Example map

Example data record

Infestation number	Access*			Density**			Size***					Other information relevant to potential control
	E	M	D	L	M	H	LC	S	M	L	VL	
1	×					×		×				1.8 m tall, east facing slope
2	×					×		×				1.5 m tall, east facing slope
3	×				×			×				1.5 m tall, east facing slope, regrown from recent aerial spraying
4	×			×			×					1.5 m tall, scattered bushes, relatively flat ground
5		×			×		×					1.5 m tall, signs of biocontrol damage, relatively flat ground
6		×				×		×				lantana in creek, some native vegetation
7			×			×		×				1.8 m tall, on south-west facing slope, some native trees present
8			×			×			×			1.8 m tall, on west facing slope, some native trees present
9	×					×			×			1.8 m tall, on west facing slope, some native trees present
10		×		×			×					1 m tall, on west facing slope, regrowth from recent slashing
11	×				×		×					1.2 m tall, on west facing slope moderately sized bushes
12	×				×		×					1.5 m tall, north-west facing slope
13	×				×			×				1.5 m tall, north-west facing slope

*Access E = easy, M = moderate, D = difficult

**Density L = low (0–10%), M = medium (11–50), H = high (› 50%)

***Size LC = localised (‹ 0.25 ha), S = small (0.25–1 ha), M = medium (1–10 ha), L = large (10–25 ha), VL = very large (› 25 ha)

Appendix 2a Recommended spray seasons

Active ingredient	Example product name	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Foliar spraying, aerial spraying and splatter gun													
Glyphosate	Roundup® Glyphosate 360 Weedmaster® Duo Credit®	×	×	❀	✓	✓	✓	✓	✓	✓	✓	❀	×
Picloram + triclopyr	Conqueror® Fightback®	×	×	×	×	×	❀	❀	✓	✓	✓	❀	×
Picloram + triclopyr + aminopyralid	Grazon® Extra	×	×	×	×	×	❀	❀	✓	✓	✓	❀	×
Picloram + 2,4-D	Tordon® 75-D	×	×	×	×	❀	✓	✓	✓	✓	✓	❀	×
Dichlorprop	Lantana 600	×	×	❀	❀	❀	✓	✓	✓	✓	✓	❀	×
Fluroxypyr	Starane® Advanced Flagship® 200 Comet® 400	×	×	×	×	❀	✓	✓	✓	✓	✓	❀	×
2,4-D amine	Amicide® 625 Amine 625	×	×	×	×	×	×	×	×	✓	✓	✓	×
Metsulfuron methyl	Brush-Off® Brushkiller™ Lynx® 600 Bushwacker® WG Savannah®	×	×	×	×	×	×	×	×	✓	✓	✓	×
Metsulfuron methyl + glyphosate	Cut-Out® Trounce®	×	×	❀	❀	❀	❀	❀	❀	✓	✓	✓	×
Aminopyralid + fluroxypyr	Hotshot®	×	×	❀	❀	❀	❀	✓	✓	✓	✓	✓	×
Basal bark and cut stump													
Picloram + triclopyr	Access®	❀	❀	✓	✓	✓	✓	✓	✓	✓	✓	✓	❀
Picloram	Vigilant® Gel	❀	❀	✓	✓	✓	✓	✓	✓	✓	✓	✓	❀
Triclopyr	Garlon® 600	❀	❀	❀	❀	✓	✓	✓	✓	✓	✓	❀	❀
2,4-D n-butyl ester	Agricrop Rubber Vine Spray®	❀	❀	❀	❀	❀	❀	❀	❀	❀	❀	❀	❀

✓ Best time to spray/treat

❀ Can spray if conditions are suitable

× Do not spray/treat

Appendix 2b Herbicide volumes tables

Method of application	Lantana density	Lantana height			
		< 0.5 m	0.5–1.0 m	1.0–1.5 m	1.5–2.0 m
High-volume and high-pressure foliar spraying (hand gun, hose and reel)	Heavy		3000 L/ha	4000 L/ha	5000 L/ha
	Medium		2000 L/ha	3000 L/ha	4000 L/ha
	Light		1000 L/ha	2000 L/ha	3000 L/ha
High-volume and low-pressure foliar spraying (knapsack and spot- spraying)	Medium		20 L/100 m²		
	Light		10 L/100 m²		
Aerial application by helicopter (boom spray)	Heavy			200 L/ha	200 L/ha
Splatter gun (approximate values to equate to registered rate)	Per bush (applicable for heavy, medium and light infestations)	4 mL (2 × 2 mL)	4–8 mL	8–12 mL	12–16 mL
Basal barking (sprayed)	Light to medium		< 100 mL/bush		
Cut stump	Light to medium	Dependent of density and thickness of stems			

Appendix 2c Other species to spray while treating lantana

Herbicide	Active/s	Reference	Method
Grazon®, DS, Conqueror®	Picloram + triclopyr	*Dow Woody Weed Guide*	Foliar spray
Grazon® Extra	Picloram + triclopyr + aminopyralid		
Hotshot®	Aminopyralid + fluroxypyr		
Ripper® 480	Glyphosate		
Starane® Advanced	Fluroxypyr		
Tordon® 75-D	Picloram + 2,4-D amine		
Statesman® 720	2,4-D amine		
Lantana 600	Dichlorprop	Lantana 600 label	
Brush-Off®	Metsulfuron methyl	Brush-Off® label	
Access®	Picloram + triclopyr	*Dow Woody Weed Guide*	Basal bark
Garlon® 600	Triclopyr		
Access®	Picloram + triclopyr	*Dow Woody Weed Guide*	Cut-stump
Garlon® 600	Triclopyr		
Vigilant® Gel	Picloram	Macspred	
Grazon® Extra	Picloram + triclopyr	*Dow Woody Weed Guide*	Aerial
Grazon® + 2,4-D amine	Picloram + triclopyr + 2,4-D amine		
Lantana 600	Dichlorprop	Lantana 600 label	
Roundup®	Glyphosate	Roundup® label	Gas gun
Brush-Off®	Metsulfuron methyl	Brush-Off® label	

						✓	✓						✓		✓		✓	✓	**African boxthorn,** *Lycium ferocissimum*
							✓										✓	✓	**Angophora regrowth,** *Angophora* spp.
						✓	✓			✓							✓	✓	**Australian blackthorn,** *Bursaria spinosa*
												✓							**Balloon cotton bush,** *Gomphocarpus physocarpus*
																	✓	✓	**Banksia,** *Banksia* spp.
												✓		✓					**Bathurst burr,** *Xanthium spinosum*
										✓				✓					**Bellyache bush,** *Jatropha gossypifolia*
								✓	✓										**Bitter bark,** *Alstonia constricta*
				✓						✓			✓		✓		✓	✓	**Blackberry,** *Rubus fruticosus*
														✓					**Blackberry nightshade,** *Solanum nigrum*
												✓							**Blue billygoat weed/blue top,** *Ageratum houstonianum*
✓	✓			✓						✓					✓				**Boneseed/bitou bush,** *Chrysanthemoides monilifera*
										✓					✓				**Bracken fern,** *Pteridium esculentum*
									✓					✓			✓	✓	**Brigalow regrowth,** *Acacia harpophylla*
				✓										✓					**Broadleaf pepper tree,** *Schinus terebinthifolius*
							✓		✓										**Brush box,** *Lophostemon confertus*
					✓	✓	✓	✓	✓								✓	✓	**Camphor laurel,** *Cinnamomum camphora*
					✓	✓		✓				✓							**Castor oil plant,** *Ricinus communis*
																	✓	✓	**Casuarina regrowth,** *Casuarina* spp.
					✓	✓	✓	✓	✓								✓	✓	**Chinee apple,** *Zizphus mauritiana*
			✓		✓		✓		✓					✓			✓	✓	**Cockspur thorn,** *Maclura cochinchinensis*
																			Cocky apple, *Planchonia careya*
		✓									✓			✓		✓	✓	✓	**Creeping lantana,** *Lantana montevidensis*
			✓							✓			✓	✓	✓	✓	✓	✓	**Crofton weed,** *Ageratina adenophora*

Appendix 2c Other species to spray while treating lantana (cont.)

Herbicide	Active/s	Reference	Method
Grazon®, DS, Conqueror®	Picloram + triclopyr	*Dow Woody Weed Guide*	Foliar spray
Grazon® Extra	Picloram + triclopyr + aminopyralid		
Hotshot®	Aminopyralid + fluroxypyr		
Ripper® 480	Glyphosate		
Starane® Advanced	Fluroxypyr		
Tordon® 75-D	Picloram + 2,4-D amine		
Statesman® 720	2,4-D amine		
Lantana 600	Dichlorprop	Lantana 600 label	
Brush-Off®	Metsulfuron methyl	Brush-Off® label	
Access®	Picloram + triclopyr	*Dow Woody Weed Guide*	Basal bark
Garlon® 600	Triclopyr		
Access®	Picloram + triclopyr	*Dow Woody Weed Guide*	Cut-stump
Garlon® 600	Triclopyr		
Vigilant® Gel	Picloram	Macspred	
Grazon® Extra	Picloram + triclopyr	*Dow Woody Weed Guide*	Aerial
Grazon® + 2,4-D amine	Picloram + triclopyr + 2,4-D amine		
Lantana 600	Dichlorprop	Lantana 600 label	
Roundup®	Glyphosate	Roundup® label	Gas gun
Brush-Off®	Metsulfuron methyl	Brush-Off® label	

												✓						**Devil's fig,** *Solanum torvum*
✓	✓					✓	✓	✓	✓			✓		✓		✓	✓	**Ecualypt regrowth,** *Eucalyptus* spp.
															✓	✓		**Fireweed,** *Senecio madagascariensis*
✓	✓				✓	✓	✓	✓	✓			✓	✓		✓		✓	✓	**Groundsel bush,** *Baccharis halimifolia*
										✓			✓						**Inkweed,** *Phytolacca octandra*
										✓							✓	✓	**Japanese sunflower,** *Tithonia diversifolia*
							✓		✓										**Leucaena,** *Leucaena leucocephala*
														✓					**Madeira vine,** *Andredera cordifolia*
✓	✓		✓							✓			✓	✓	✓	✓	✓	✓	**Mistflower,** *Ageratina riparia*
												✓		✓			✓	✓	**Mother-of-millions,** *Bryophyllum* spp.
										✓		✓		✓					**Noogoora burr,** *Xanthium pungens*
					✓									✓			✓	✓	**Paddy's lucerne,** *Sida rhombifolia*
										✓		✓	✓						**Parthenium weed,** *Parthenium hysterophorus*
					✓	✓	✓	✓	✓	✓									**Privet (broadleaf),** *Ligustrum lucidum*
				✓	✓	✓	✓	✓	✓	✓			✓				✓	✓	**Rubbervine,** *Cryptostegia grandiflora*
					✓												✓	✓	**Siam weed,** *Chromolaena odorata*
											✓		✓				✓	✓	**Sicklepod,** *Senna obtusifolia*
										✓			✓				✓	✓	**Smartweed,** *Persicaria lapathifolia*
												✓		✓					**Snakeweed,** *Stachytarpheta* spp.
												✓			✓	✓	✓	✓	**Thistles,** *Cirsium* spp., *Carthamus* spp.
																	✓	✓	**Tobacoo weed,** *Elephantopus scaber*
						✓	✓	✓	✓					✓			✓	✓	**Wattle regrowth,** *Acacia* spp.
					✓		✓						✓				✓	✓	**Wild tobacco tree,** *Solanum mauritianum*

Appendix 3 Record of ground distribution (application) of herbicides

Based on *Agricultural Chemicals Distribution Control Act 1966* (Queensland)

Note: This record must be kept in a safe place for at least two years after the distribution is carried out.

1. Date of distribution _____

2. Name of licensed operator _____

3. Name of client _____

4. Address of client _____

_____ Postcode _____

5. Location (Real property description and map reference) _____

_____

6. Start time _____ 7. Finish time _____ 8. Block number _____

9. Crop/situation _____ 10. Area treated _____

11. Purpose/target (e.g. to treat lantana, broad leave weeds) _____

12. Type of equipment (e.g. boom, hand gun, knapsack) _____

_____ 13. Tank size _____

14. Herbicide mixture

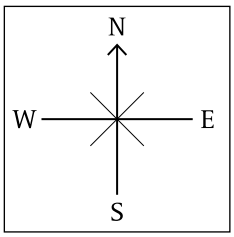
Spray mixture ingredients **A. Herbicide product used**	**Batch number** (where listed)	**Application rate** (e.g. per ha or per 100 L)	**Total volume**
Trade name			
Active constituent			
Manufacturer			
APVMA number			
B. Diluent (e.g. water/oil)			
C. Wetting agent			
D. Other ingredients (e.g. spreader, emulsifier etc)			

15. Weather conditions at commencement of distribution

Wind speed
- ☐ 0 Calm ‹ 1 km
- ☐ 1 Light air 1–5 km
- ☐ 2 Slight breeze 6–11 km
- ☐ 3 Gentle breeze 12–20 km
- ☐ 4 Gusty › 20 km

Temperature
- ☐ Cold (‹ 5 ˚C)
- ☐ Cool (5–15 ˚C)
- ☐ Warm (15–25 ˚C)
- ☐ Hot (25–30 ˚C)

Wind direction



16. Change in weather conditions once distribution commences (record changes in wind speed or direction once ground distribution has commenced including the time when the change occurred)

_____

_____

17. Additional notes _____

_____

_____

18. Signature _____ Date _____

19. Property map

An example of the type of information that might be listed on the property map could include, but need not be limited to, advice where 'north' lies in relation to the property, directional signs and distances from the nearest towns or cities, a rough sketch of the various blocks on the property and location of the farm residence.

Draw map here

Appendix 4 Table of active constituents registered for use on lantana

Active constituents registered for use on lantana	Product examples*
2,4-D/hydrocarbon liquid	Agricrop Affray 300
2,4-D as sodium salt	Tornado DF
2,4-D as the triisopropanolamine salt/picloram as the triisopropanolamine salt	Tordon® 75-D
2,4-D dimethylamine salt	Nufarm 2,4-D 720 Selective
2,4-D present as the diethanolamine and triethanolamine salt	Nufarm Emicide 625-Low Selective
2,4-D present as the diethanolamine salt	Ospray 2,4-D Low Odour 500 Selective
2,4-D present as the dimethyl amine salt	Baton, Dow Agrosciences Amine 625
2,4-D present as the dimethylamine and diethanolamine salt	Nufarm Surpass® 475, Nufarm Amicide® 625 Selective
2,4-D present as the dimethylethanolamine salt and dimet	Statesman® 720
2,4-D present as the isopropylamine salt	Smash 225, Mate 300, Abound® 400
Alkyl polyglycoside surfactant/glyphosate present as the isopropylamine salt	Farmoz Wipe-Out® 360 Non-residual
Aminopyralid present as hexyloxypropylamine salt/ picloram present as the hexyloxypropylamine salt/ triclopyr present as the butoxyethyl ester	Grazon® Extra
Aminopyralid present as triisopropanolamine salt/ fluroxypyr as the methyl heptyl ester/hydrocarbon liquid	Hotshot®
Dichlorprop present as the potassium salt	Agricrop Lantana 600
Fluroxypyr 1-methyl heptyl ester/hydrocarbon liquid	Kenso Agcare Fluroken 200
Fluroxypyr as the methyl heptyl ester	Starane® Advanced
Fluroxypyr as the methyl heptyl ester/hydrocarbon liquid	Starane® 200, Nufarm Comet® 200
Fluroxypyr as the methyl heptyl ester/hydrocarbon liquid/ n-methyl-2-pyrrolidone	Nufarm Comet® 400, Decoy 400®
Glyphosate isopropylamine salt	Yates Non-Selective Zero Glyphosate 360 and 490 G/L Weedspray
Glyphosate present as the isopropylamine and mono-ammoni	Nufarm Credit® Broadhectare, Weedmaster® Duo Dual Salt
Glyphosate present as the isopropylamine salt	Roundup®, Nufarm Glyphosate 360, Farmoz Wipe-Out® 450, Ripper® 480, Fire-Up 510, Sickle™ 540, Roundup® Biactive™, Roundup® Dry, Kenso Agcare Ken-Up Dry 680 Wg, Macspred
Glyphosate present as the mono-ammonium salt/ metsulfuron-methyl	Trounce® Brush-Pack by Monsanto
	Dupont Cut-Out® Brush Controller
Glyphosate present as the monoethanolamine salt	Roundup® Max by Monsanto, Farmoz Wipe-Out® Plus

Active constituents registered for use on lantana	Product examples*
Glyphosate present as the potassium salt	Touchdown® Hi Tech
	Roundup PowerMax® By Monsanto
Hydrocarbon liquid/picloram as isooctyl ester/triclopyr present as the butoxyethyl ester	Access®
Metsulfuron-methyl	Dupont Brush-Off®, Farmoz Bushwacker® Brush Control, Farmoz Lynx® Wg, Farmoz Bushwacker® WG
Picloram hexyloxypropylamine salt/triclopyr present as the butoxyethyl ester	Genfarm Triclopyr/Pic
Picloram present as the hexyloxypropylamine sal/ triclopyr butoxyethyl ester	Gallop
Picloram present as the hexyloxypropylamine salt/ triclopyr present as the butoxyethyl ester	Grazon® Ds, Grass-Up™, Farmoz Fightback®, Nufarm Conqueror®
Triclopyr present as the butoxyethanol ester	Triclon 600
Triclopyr present as the butoxyethyl ester	Garlon® 600, Farmoz Safari® 600 EC
2,4-D/hydrocarbon liquid	Agricrop Affray 300

*Various other products containing these active constituents are registered for use on lantana in various situations. Refer to the Australian Pesticides and Veterinary Medicines Authority up-to-date list of all herbicide products registered for use on lantana. Visit the website at www.apvma.gov.au

Always read the label carefully before use and only use a herbicide in accordance with label directions.

Appendix 5 Relevant legislation, policies, strategies and programs

The following tables are adapted from the 'Plan to Protect Environmental Assets from Lantana, which can be found at: www.environment.nsw.gov.au/lantanaplan

The main commonwealth and state legislation, policies, strategies and programs that influence lantana management are presented below.

National/state	Strategy/Act	Background/purpose
National	*Agricultural and Veterinary Chemicals Code Act 1994* (Agvet Act)	All pesticides, including herbicides, insecticides and fungicides, used, supplied or distributed in Australia must be registered under the Agvet Act by the Australian Pesticides and Veterinary Medicines Authority [APVMA: formerly the National Registration Authority for Agricultural and Veterinary Chemicals (NRA)].
	Australian Weeds Strategy	The Australian Weeds Strategy provides a framework to establish consistent guidance for all parties, and identifies priorities for weed management across the nation with the aim of minimising the impact of weeds on Australia's environmental, economic and social assets.
	Biological Control Act 1984	The use of non-native biological organisms (the agent) to control a specific pest or weed species (the target) is governed by the *Biological Control Act 1984*. This Act establishes a detailed set of procedures and a framework for the selection of agents (through host-specificity testing), the importation of agents into Australian quarantine and the intentional release of agents from quarantine.
	Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Provides a national framework for environmental management (including the recognition of nationally threatened species and ecological communities) directing resources towards the delivery of improved environmental protection.
	Weeds of National Significance (WoNS)	The WoNS were determined from a list of 71 major weed species, which were derived using set criteria. A species was included if it: threatened the profitability or sustainability of Australia's principal primary industries threatened conservation areas or environmental resources of national significance required remedial action across several states and territories constituted a major threat to Australia's biodiversity.

Goals/actions
Before any chemical or product (e.g. commercially formulated pesticide) is registered for use, supply or distribution, the APVMA is required under the Agvet Act to conduct a rigorous assessment of potential impacts on the environment, human health and trade.
The goals of the Australian Weeds Strategy are to: • prevent new weed problems • reduce the impact of existing priority weed problems • enhance Australia's capacity and commitment to solve weed problems.
Prior to allowing importation and intentional release from quarantine, the impacts of the agent on the target as well as non-target species are assessed. In addition, the importation of biological control agents requires approval from Biosecurity Australia (part of the Department of Agricultural Forestry and Fisheries Australia), the Australian Quarantine and Inspection Service, and the Department of Environment, Water, Heritage and Arts. The Australian Weeds Committee, in conjunction with the Natural Resource Management Standing Committee (formerly the Standing Committee on Agriculture and Resource Management) must also approve all biological control proposals before any control is attempted. Approval includes wide consultation with all stakeholders.
With respect to threatened species and ecological communities, the EPBC Act provides for: • identification and listing of threatened species and threatened ecological communities • development of recovery plans for such species and ecological communities • recognition of key threatening processes • reducing these processes through threat abatement plans.
Lantana camara was listed as one of the 20 WoNS in 2000 (see Thorp and Lynch 2000), following which a national strategy was produced. The national strategy for lantana has five goals, which are to: • minimise impact • prevent the sale • increase community awareness • prevent spread • coordinate management.

Appendix 5 Relevant legislation, policies, strategies and programs (cont.)

National/state	Strategy/Act	Background/purpose
New South Wales	*Noxious Weeds Act 1993*	This Act provides for the identification, classification and control of noxious weeds in NSW. The lead agency for this Act is the NSW Department of Primary Industries (formerly NSW Agriculture), with the Act administered by Local Control Authorities (usually local councils, but can be a combination of council areas).
	NSW National Parks and Wildlife Act 1974	This Act established the National Parks and Wildlife Service (NPWS), now part of DECC. The Parks and Wildlife Division of DECC is responsible for the care, control and management of all national parks, historic sites, nature reserves, Aboriginal areas, state conservation areas, karst conservation reserves, marine parks and regional parks within NSW.
	Pesticides Act 1999	The *Pesticides Act 1999* regulates the use of all pesticides in NSW, after the point of sale. This includes pesticides used in agriculture, on public lands and on domestic and commercial premises.
	Threatened Species Conservation Act 1995 (TSC Act)	In January 1996, the *NSW Threatened Species Conservation Act 1995* (TSC Act) commenced with the purpose of conserving threatened species, populations and ecological communities in NSW. Contained within the TSC Act are three schedules: Schedule 1 contains lists of critically endangered species and communities, endangered species, populations and communities, and extinct species; Schedule 2 contains lists of vulnerable species and communities; and Schedule 3 contains a list of key threatening processes (KTPs). In 2004, several additional amendments were made to the TSC Act. The amendments relevant to this Plan are: i) the preparation of a TAP is no longer mandatory; and ii) the development of a Priorities Action Statement (PAS). The PAS outlines recovery and threat abatement actions for the biodiversity listed under the TSC Act.

Goals/actions
The Act defines the roles of government, councils, private landholders and public authorities in the management of noxious weeds. The Act sets up categorisation and control actions for the various noxious weeds: • the control objective for weed control Class 1 is to prevent the introduction and establishment of those plants in NSW • the control objective for weed control Class 2 is to prevent the introduction and establishment of those plants in parts of NSW • the control objective for weed control Class 3 is to reduce the area and the negative impact of those plants in parts of NSW • the control objective for weed control Class 4 is to minimise the negative impact of those plants on the economy, community or environment of NSW • the control objective for weed control Class 5 is to prevent the introduction of those plants into NSW, the spread of those plants within NSW or from NSW to another jurisdiction.
The aims of weed management undertaken by the National Parks and Wildlife Service are to: • conserve biodiversity and cultural heritage on-park • minimise the spread of weeds to and from neighbouring properties • raise community awareness of the impacts of weeds • encourage community involvement • conform to legislative requirements for the control of noxious weeds.
Additional amendments have been included under the Pesticides Regulation 1995 to include: • Pesticide record keeping: records must be kept by all people who use pesticides for commercial or occupational purposes such as on a farm, on produce, or as part of their occupation or business. • Pesticide training: people who use pesticides in their business or as part of their occupation must be trained in how to use those pesticides. Any person employed or engaged to use pesticides must also be trained. • Pesticide notification: from 1 February 2007, new notification requirements applied to pesticides applications by public authorities in outdoor public places and to pesticide applications by licensed pest management technicians in common areas of multi-occupancy residential complexes.
The objectives of the TSC Act are to: • conserve biological diversity and promote ecologically sustainable development • prevent the extinction and promote the recovery of threatened species, populations and ecological communities • protect the critical habitat of those threatened species, populations and ecological communities that are endangered • eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities • ensure that the impact of any action affecting threatened species, populations and ecological communities is properly assessed • encourage the conservation of threatened species, populations and ecological communities by the adoption of measures involving cooperative management.

Appendix 5 Relevant legislation, policies, strategies and programs (cont.)

National/state	Strategy/Act	Background/purpose
Queensland	*Agricultural Chemicals Distribution Control Act 1966*	The Queensland Department of Employment, Economic Development and Innovation (DEEDI) administers the *Agricultural Chemicals Distribution Control Act 1966*. This Act controls aerial distribution (spraying, spreading or dispersing) of agricultural chemicals from aircraft to which aerial equipment is installed or attached. The Act also controls ground distribution of herbicides from ground equipment.
	Biological Control Act 1987	The *Biological Control Act 1987* provides for biological control of agricultural pests for the protection of the environment. This Act is jointly administered by DEEDI and Department of Environment and Resource Management (DERM). The Act provides for the case of biological control agents to control agricultural pests through the declaration of target organisms and the declaration and release of agent organisms to combat them. The Act also establishes the Queensland Biological Control Authority and prescribes its powers and functions.
	Chemical Usage (Agricultural and Veterinary) Control Act 1988 and Chemical Usage (Agricultural and Veterinary) Control Regulation 1999	This legislation, administered also by DEEDI, provides for controls over the use of agricultural and veterinary chemical products by all chemical users.
	Land Protection (Pest and Stock Route Management) Act 2002	This Act provides a framework and powers for improved management of weeds and pest animals. It governs the actions for the control and management of declared plants and animals in Queensland. It also provides local governments with the legal instrument they need to enforce the management of high-priority weeds and pest animals.

Goals/actions
A key control mechanism for aerial distribution of agricultural chemicals is the dual licensing of both the pilots, who are in command of aircraft from which aerial distribution is carried out, and the aerial agricultural businesses and individual contractors who carry on the business of aerial distribution, or direct or authorise an aircraft to be used to carry out aerial distribution of agricultural chemicals in Queensland.
The Act aims to provide a link with complementary legislation in the other states and the Northern Territory to ensure a uniform approach to biological control throughout Australia.
In general terms, agricultural chemical products are pesticides (including insecticides, fungicides and herbicides) that are used to control pests in food and fibre crops, aquatic situations and non-agricultural situations (e.g. commercial land, buildings). It should be noted that any substance used to control pests in these situations would be considered to be an agricultural chemical product. *The Chemical Usage Act 1988* allows all persons to use registered agricultural chemical products in certain ways (e.g. lower rate of use) that are not in accordance with the instructions on the label approved by Australian Pesticides and Veterinary Medicines Authority (APVMA) (i.e. off-label), without these uses being considered offences under the legislation. These off-label use allowances are limited. Refer to s. 13B of the *Chemical Usage Act 1988* (compliance with instructions). No other off-label use is permitted unless a permit for the use has been issued by APVMA. Agricultural chemical products that have not been registered by APVMA must not be used, unless a permit has been issued for use.
This legislation is administered by Biosecurity Queensland to ensure the fight against invasive pests in Queensland is coordinated, consistent, and does not waste precious resources. An important function of the Act is the ability to declare plants and animals that are considered serious or potentially serious pests in Queensland. Biosecurity Queensland imposes a range of restrictions on declared plants and animals in Queensland (including introduction, possession and sale) but allows certain activities under declared pest permits. All species of lantana, including ornamental varieties, have been declared in Queensland as Class 3 pest plants under the *Land Protection (Pest and Stock Route Management) Act 2002*. Class 3—pest plants established in Queensland that have or could have adverse economic, environmental or social impacts (including in another state). Because it is a Class 3 pest plant, it is an offence under the Act to introduce, release or supply (give, sell or otherwise supply) lantana (all species). It is also an offence to move or transport on a road anything containing reproductive parts of a Class 3 pest plant, unless steps have been taken to restrict the release of such reproductive material. As of 1 November 2003 all species of lantana were prevented from sale in Queensland. It is not an offence to hold a Class 3 pest plant (i.e. if lantana is already growing on your property), unless it threatens an environmentally significant area (as defined in a local government area Pest Management Plan). If the Class 3 pest threatens an environmentally significant area, the landowner may be required to take steps to control that pest on their land.

Appendix 5 Relevant legislation, policies, strategies and programs (cont.)

National/state	Strategy/Act	Background/purpose
Queensland	*Nature Conservation Act 1992* (NC Act)	In Queensland, legislation about conserving and managing native animals and plants and declaring and managing protected areas such as national parks is under the NC Act. This replaced the *Fauna Conservation Act 1974*, *National Parks and Wildlife Act 1975*, *Native Plants Protection Act 1930* and provisions of the *Land Act 1994* relating to environmental parks. The NC Act is based on principles to conserve biological diversity, ecologically sustainable use of wildlife, ecologically sustainable development and international criteria developed by the World Conservation Union (International Union for the Conservation of Nature and Natural Resources) for establishing and managing protected areas.
	Vegetation Management Act 1999	This Act is in place to regulate the clearing of vegetation in Queensland. The regional ecosystems classification scheme and the associated Biodiversity Planning Assessments are part of the biodiversity planning framework that has been developed to assist Queensland DERM to plan for biodiversity. The framework has been incorporated into planning initiatives including the development of guidelines for clearing on leasehold lands under the *Lands Act 1994* and the *Vegetation Management Act 1999*; the assessment of the comprehensiveness, adequacy and representativeness of the conservation reserve network; and as a guide for proactive conservation.

Goals/actions
The NC Act's objective is the conservation of nature. This is to be achieved by an integrated and comprehensive conservation strategy involving: • gathering, researching and disseminating information on nature, identifying critical habitats and areas of major interest, and encouraging the conservation of nature by education and cooperative involvement of the community • dedication and declaration of areas representative of the biological diversity, natural features and wilderness of Queensland as protected areas • managing protected areas • protecting native wildlife and its habitat • ecologically sustainable use of protected wildlife and areas • recognition of the interest of Aboriginal and Torres Strait Islanders in nature and their cooperative involvement in its conservation • cooperative involvement of landholders.
Regional ecosystems were defined by Sattler and Williams as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The framework is dynamic and is regularly reviewed as new information becomes available. The Regional Ecosystem Description Database lists the status of regional ecosystems as gazetted under the *Vegetation Management Act 1999* (their vegetation management status) and their biodiversity status as recognised by the Environmental Protection Agency. The *Vegetation Management Act 1999* status is based on an assessment of the pre-clearing and remnant extent of a regional ecosystem. The biodiversity status is defined by the Environmental Protection Agency and is based on an assessment of the condition of remnant vegetation in addition to the pre-clearing and remnant extent of a regional ecosystem. The current biodiversity status is given on the Regional Ecosystem Description Database.

Appendix 5 Relevant legislation, policies, strategies and programs (cont.)

National/state	Strategy/Act	Goals/actions
Australian Capital Territory	*Pest Plant and Animal Act 2005*	Lantana is on the declared pest plant list under the ACT *Pest Plant and Animal Act 2005*.
Northern Territory	*Weeds Management Act 2001*	The Northern Territory has declared *L. camara* under the *Weeds Management Act 2001*. It is declared at two levels: • Class B Noxious Weed (regional declaration): growth and spread to be controlled outside town areas. • Class C Noxious Weed: not to be introduced to the Northern Territory. Declared weeds are restricted from sale in the Northern Territory.
South Australia	*Natural Resources Management Act 2004*	*Lantana camara* is a declared plant in South Australia. See above under the National Containment Zones Project for lantana.
Tasmania	*Weed Management Act 1999*	*Lantana camara* is declared under the *Weed Management Act 1999*. Lantana may not be imported into Tasmania, and its sale or other supply is not permitted. Landholders may be required to take steps to control lantana on their property.
Victoria	*Catchment and Land Protection Act 1994*	*Lantana camara* is declared under the *Catchment and Land Protection Act 1994*. Trade and distribution in lantana and materials containing it are prohibited.
Western Australia	*Agricultural and Related Resources Protection Act 1976*	*Lantana camara* is declared in Western Australia under the *Agricultural and Related Resources Protection Act 1976*. The movement of plants or their seeds is prohibited within the state.

Appendix 6 Lantana poisoning information sheet

Lantana poisoning

Lantana is a serious health risk to stock because of its toxicity. Red flowered varieties are usually more toxic than pink varieties, but results are variable and all lantana colour forms should be treated as poisonous.

Most lantana poisoning occurs when stock unfamiliar with the plant are introduced to areas where lantana is found. Young animals are most at risk. Stock bred in lantana-infested country tend to avoid it unless forced to eat the weed through lack of adequate food.

Species affected

Species affected by lantana poisoning include cattle, sheep, goats, guinea pigs and rabbits. Further research is needed to determine the long-term effects of lantana on goats and camels. Children can also be poisoned by eating berries, but their symptoms differ to those of livestock.

Sheep showing symptoms of lantana poisoning.

Toxicity

Significant lantana toxins are the triterpene acids: lantadene A (rehmannic acid), lantadene B, and their reduced forms. A toxic dose for a 500 kg cow varies from about 5 to 20 kg of fresh leaf (one per cent or more of the animal's body weight), depending on the toxin content of the lantana eaten.

Symptoms of lantana poisoning in cattle

Symptoms of lantana poisoning depend on the amount and type of lantana consumed and the intensity of sunlight to which the animals have been exposed. Signs can appear after one feed and, in acute cases, within 24 hours. In severe cases, death may occur in two to four days, but it is more common for affected animals to take one to three weeks to die if untreated.

Affected animals may:

- avoid sunlight (photophobia)
- stop eating
- appear sluggish, weak and depressed
- urinate frequently
- become constipated (most commonly) or have diarrhoea with strong-smelling black fluid faeces in severely affected animals
- become dehydrated.

Cattle may become sun-sensitive and their skin may blister after eating lantana.

Poisoned animals may show signs of:

- excessive skin sensitivity to sunlight (photosensitisation)
- liver damage
- yellow discolouration (jaundice) of the whites of the eyes and gums, and skin of the nose and mouth
- reddening and inflammation of the unpigmented (white) skin. Muzzle may become inflamed, moist, ulcerated and very painful (pink nose)
- in severe cases, skin may slough (fall off) leaving raw ulcerated surfaces
- swelling of unpigmented areas of the ears and eyelids
- reddening and discharge from the eyes (conjunctivitis)
- ulceration of the tip and under surface of the tongue (if unpigmented)
- blow fly and bacterial invasion of raw, exposed flesh, in chronic cases.

Animals killed by lantana poisoning display the following post-mortem symptoms:

- yellow discolouration of tissues (jaundice)
- hard, dry, mucus-covered faecal masses in the large intestine
- dry, undigested plant material in the rumen
- swollen and discoloured (yellow to orange) liver
- swollen gall bladder
- swollen and pale kidneys that turn green when exposed to air and cutting
- ulcerated cheeks, muzzle, nostrils, tongue and gums (in severe cases in cattle).

Calves poisoned by lantana stop eating and become weak and depressed.

Post-mortem changes—note the enlarged gall bladder and yellowing of all tissues.

Jaundice (yellow discolouration) of the eye.

Photosensitisation (pink nose) in a cow.

Treatment

Contact your vet quickly!

If animals lose their appetite, stop drinking, show signs of jaundice and/or develop reddening of the muzzle, they should be moved to lantana-free areas and kept in the shade. Unless treated quickly, severely affected cattle almost invariably die within 10 days of eating the plant. Even if an animal's lesions begin to heal and their liver function appears to return to normal, many cattle will die up to six weeks after being poisoned.

Effective treatment may include:

- giving intravenous fluids and encouraging the animal to eat
- treating skin damage with antibiotics and sunscreens. Other drugs can provide relief but are available only on veterinary prescription
- drenching with an activated charcoal slurry (2.5 kg activated charcoal in 20 litres of electrolyte replacement solution for cattle; 500 g in four litres for sheep and goats).

Activated charcoal is an effective but expensive poisoning antidote and a second dose may be required 24 hours after the first if the animal has not improved. Bentonite can be substituted for activated charcoal but is not as effective and may take up to two days longer to produce the same results. Use the same dose, as for charcoal, in a slurry with water.

The outlook for recovery is good provided animals are treated quickly. Delay reduces the effectiveness of treatment because kidney function may be seriously damaged.

Preventing lantana poisoning

To prevent your animals from being poisoned by lantana:

- treat all lantana as potentially poisonous
- keep your property lantana free
- ensure stock have adequate feed
- do not put new or young stock in areas where lantana is present
- act quickly if poisoning is suspected—call your vet.

Appendix 7 Lantana biocontrol table

Scientific name/common name	Locations where established *locations where release is continuing
Teleonemia scrupulosa leaf-sucking bug	From Cairns to Wollongong and around Darwin.
Octotoma scabripennis leaf-mining beetle	Subtropical shady coastal areas from Atherton to Kiama.
Uroplata girardi leaf-mining beetle	From Cape Tribulation to Sydney and around Darwin.
Ophiomyia lantanae fruit-mining fly	From Torres Strait Island to Eden, also around Darwin and Katherine and Perth and Geraldton.
Leptobyrsa decora sap-sucking bug	Only in high altitude, drier areas of Atherton Tablelands in Queensland.
Prospodium tuberculatum rust	Atherton Tablelands, Paluma, Kin Kin to Port Macquarie.
Phenacoccus parvus mealy bug	Isolated populations from Atherton to Kempsey and around Perth.
Aconophora compressa stem-sucking bug	Atherton Tablelands, Mount Fox, Miriam Vale to South West Rocks, and around Sydney.
Calycomyza lantanae leaf-mining fly	From Torres Strait to Kempsey and around Darwin and Katherine.
Hypena laceratalis leaf-feeding moth	From Mossman to Kempsey.
Neogalea sunia leaf-feeding moth	From Atherton Tablelands to Eden.
Salbia haemorrhoidalis leaf-feeding moth	From Mossman to Coffs Harbour.
Lantanophaga pusillidactyla flower-feeding moth	From Cooktown to Merimbula and around Darwin and south-west Western Australia.
Epinotia lantana flower and bud-feeding moth	From Cooktown to Ulladulla and around Darwin.
Octotoma championi leaf-mining beetle	Atherton Tableland and Myall Lakes to Merimbula.
Uroplata fulvopustula leaf-mining beetle	Only in North Queensland Mossman to Paluma.
Falconia intermedia leaf-sucking bug	Only on Atherton Tablelands.
Ophiomyia camarae leaf-mining fly	Established at various sites from from Atherton Tablelands to Rockhampton.

Preferred habitat	Lantana type affected	Effectiveness	Greatest seasonal damage
Warm dry areas such as central and southern Queensland, central New South Wales.	Prefers white, red and pink-edged red over pink	High	Late summer to autumn
Prefers mild conditions.	All varieties	High	Late summer to autumn
Warm humid areas of the tropics, and subcoastal regions.	All varieties	High	Late summer to autumn
Moist, warm areas where lantana flowers readily.	All varieties	High	Late summer to autumn
Sunny, open, dry, high altitude areas in the tropics.	All varieties	High	Late summer to autumn
Moist areas where leaves are wet for 9–15 hours, and temperatures of at least 20 °C.	Common pink only	Potentially high	In summer months when rainfall is higher
Drier regions of southern Queensland and northern New South Wales.	All varieties	High	
Mild, dry areas.	All varieties	High	Spring and early summer
Tropical Queensland, preferring warm moist areas.	All varieties	Medium	Late summer to autumn
Warm, moist areas.	All varieties	Low	Late summer to autumn
Warm, semi-dry areas, subcoastal regions.	All varieties	Low	Late summer to autumn
Warm, moist regions of the tropics, not found in drier subcoastal regions.	Al varieties	Low	Late summer to autumn
Warmer coastal regions where lantana flowers readily.	All varieties	Low	Late summer to autumn
Warmer coastal areas where lantana flowers readily.	All varieties	Low	Late summer to autumn
Cool, shady, moist conditions.	All varieties	Low	Late summer to autumn
Warm, moist areas.	All varieties	Low	Late summer to autumn
Warm, humid areas where plants are in leaf all year round.	All except common pink	Unknown	Late summer to autumn
Warm humid areas where plants are healthy and in leaf all year round.	All varieties	Unknown	Late summer to autumn

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