Blackberry Control Manual

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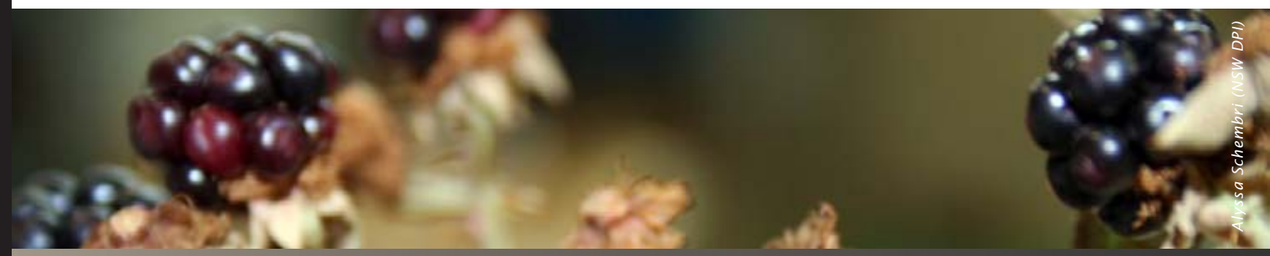
Birgitte Verbeek (NSW DPI)



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Weeds of National Significance

Blackberry Control Manual

Penny Richards (DPI, Victoria)

Management and control options for blackberry (*Rubus* spp.) in Australia

State Government Victoria
Department of Primary Industries

National Blackberry Program

Australian Government

This manual has been produced by NSW Department of Primary Industries, the Blackberry Technical Reference Group and the National Blackberry Taskforce, with funding from the Australian Government. It is part of the Weeds of National Significance (WoNS) National Blackberry Program, coordinated by the National Blackberry Coordinator, Department of Primary Industries, Victoria.

For further information on the WoNS National Blackberry Program visit the Weeds Australia website at
www.weeds.org.au/WoNS/blackberry

Copies of this manual can be downloaded or ordered from the above website.

Disclaimer

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Weeds of National Significance
June 2009

This manual has been produced by NSW Department of Primary Industries, the Blackberry Technical Reference Group and the National Blackberry Taskforce with funding from the Australian Government *Defeating the Weed Menace* program, and supported by Department of Primary Industries, Victoria.

State Government Victoria Department of Primary Industries

National Blackberry Program

Australian Government

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Importance of site assessment

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Dispersal of blackberry seeds by emus and foxes

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To retreat or not

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Consider the long-term effects when selecting herbicides

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The Western Australia experience

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An example of blackberry management in practice

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Foreword

The manual will be a valuable guide for the management and control of the weedy blackberry species in Australia.

Blackberry has been recognised as a Weed of National Significance (WoNS) in Australia because of its high degree of invasiveness, its aggressive spread, and its economic and environmental impacts. Blackberry seriously threatens both agricultural and natural ecosystems. It is estimated that annual primary production losses and blackberry control cost at least $70 million (CRC 2006).

For successful blackberry management in Australia, the greatest need is to understand that there are 26 introduced *Rubus* species in Australia. Although blackberry, as a long-established weed, may have reached the limits of its potential range in Australia, some individual species may spread further within these climatic limits. For successful control and management of this weed it is important that we are able to recognise the different species. The development of the Blackberry Identification CD-ROM by Robyn and Bill Barker of the Department for Environment and Heritage, South Australia was a valuable step forward.

The WoNS National Blackberry Taskforce recognises that the challenges for blackberry management are to prevent further spread of the blackberry species, contain existing infestations, and rehabilitate treated areas to prevent reinfestation. To achieve success in management it will also be essential that effective biological controls continue to be developed. We will need to be innovative in our future research programs.

Designed to help provide effective management solutions for blackberry within the context of integrated weed management, this manual brings together detailed information about the plant itself, as well as best practice information about existing control and management options. By reading this document you will discover that there is no one best method for control; instead, there is a range of factors that need to be considered and weighed up for each particular situation.

This manual is a living document that will be reviewed and updated as we gain new knowledge and a better understanding of how to control blackberry and prevent its spread. As new information becomes available, we will endeavour to place it on our web page (**www.weeds.org.au/WoNS/blackberry**) so that you have the most up-to-date information at your finger tips.

The National Blackberry Taskforce is aware that the task ahead to control and manage this weed is formidable, but we will only win if we give it a go.

A very big thanks to all the people who have contributed to developing the manual.

Alex Arbuthnot AM

Chair, National Blackberry Taskforce

A guide to using this manual

This manual is designed to provide current information on blackberry best practice management for land managers, weeds officers, extension services and others involved in the management of blackberry.

The information presented is based on published information, existing research and the experiences of individuals and organisations currently managing blackberry in Australia.

The manual is divided into six parts that are colour coded to help access information quickly. A summary page is provided at the start of each section to give the reader an overview of the information contained in the section.

All key references for this manual are contained in Part 6 (p. 78).

The six parts of this manual

Part 1:
Blackberry profile

- an overview of blackberry in Australia
- the problems, benefits and costs of blackberry
- the current and potential distribution of blackberry in Australia
- a description of the physical characteristics, life cycle, reproduction and spread of blackberry.

Part 2:
Identification of blackberry (*Rubus*) species in Australia

- an overview of the *Rubus* genus in Australia
- a list of all known *Rubus* species present in Australia
- information to help differentiate between species in the *Rubus* genus
- the importance of identifying *Rubus* species.

Part 3:
Developing a blackberry management plan

- an outline of the steps involved in developing a blackberry management plan:
  - Assess the problem.
  - Prioritise the areas for management.
  - Set goals.
  - Prepare, document and implement an integrated plan.
  - Monitor, record, retreat and rehabilitate.

Part 4:
Blackberry control practices

- an overview of the control practices available for blackberry:
  - herbicides
  - physical methods
  - biological control.

Part 5:
An example of blackberry management in practice

- an example of how the information presented throughout the manual can be used in practice to deliver positive weed management and environmental and social outcomes.

Part 6:
Further information

- references, glossary and acronyms
- appendices are attached at the end of the manual.

Contents

Acknowledgments | **2**

Foreword | **5**

A guide to using this manual | **6**

Part 1:
Blackberry profile

1.1 Blackberry in Australia | **10**

1.2 Description | **14**

1.3 Lifecycle, reproduction and spread | **16**

Part 2:
Identification of blackberry (Rubus) species in Australia

2.1 The genus *Rubus* in Australia | **20**

2.2 Identifying species | **22**

Part 3:
Developing a blackberry management plan

3.1 Developing a management plan | **28**

3.2 Assess the problem | **29**

3.3 Prioritise the areas for management | **33**

3.4 Set goals | **35**

3.5 The management plan | **36**

3.6 Monitor and evaluate | **37**

3.7 Follow up and rehabilitate | **37**

Part 4:
Blackberry control practices

4.1 Control with herbicides | **39**

4.2 Physical control methods | **57**

4.3 Biological control | **64**

Part 5:
An example of blackberry management in practice

5.1 Introduction | **71**

5.2 The problem | **71**

5.3 GRILCO's approach | **71**

5.4 What was done | **72**

5.5 Future plans | **77**

Part 6:
Further information

Glossary | **79**

Acronyms and abbreviations | **80**

References and further reading | **81**

Appendices

1 Noxious weed legislation for blackberry | **83**

2 Weed management: collecting blackberry specimens for identification | **85**

3 List of State herbaria | **87**

4 Weed management: helpsheet for using the blackberry Lucid Key | **88**

5 Field data sheet | **90**

6 Establishing photo points | **91**

7 Visual assessment of density | **92**

8 Herbicide resistance | **93**

9 Contacts for State/Territory agencies | **94**

10 Calibrating equipment for spraying blackberry | **95**

11 Information on hollow-cone orifice discs for handguns @ 14 bar (1400 kPa) | **96**

Case studies

The following case studies can be found throughout the manual and provide examples of how to implement the principles recommended within each part.

Part 1:
Blackberry profile

Impact of blackberry | **18**

Part 2:
Identification of blackberry (Rubus) species in Australia

Importance of blackberry identification | **26**

Part 3:
Developing a blackberry management plan

Importance of site assessment | **28**

A community approach to developing a blackberry management plan | **29**

Mapping of blackberry in the Nungatta Valley, NSW | **32**

Dispersal of blackberry seeds by emus and foxes | **36**

To retreat or not | **37**

Part 4:
Blackberry control practices

Consider the long-term effects when selecting herbicides | **40**

The Western Australia experience | **41**

Tumbarumba Shire Council | **42**

Examples of using herbicides to control blackberry | **48**

Use of the splatter gun | **54**

The Spraying Mantis | **55**

The Maatsuyker Island experience | **56**

Improving access for controlling blackberry | **58**

Huonville Landcare Group | **59**

Manual removal of blackberry on a Melaleuca floodplain | **60**

Using goats for blackberry control | **62**

Burning blackberry | **64**

Outcomes of biological control in Victorian studies | **66**

Integrating biological control with chemical control methods | **68**

Integrating methods to control a range of blackberry species | **69**

Part 1

Blackberry profile

Summary

- Blackberry belongs to a large genus (group of species) of plants called *Rubus* that includes raspberry, dewberry and loganberry.
- In Australia, the *Rubus* genus includes native species and those originating in Europe, North America and Asia.
- This manual deals with the known weedy *Rubus* species in Australia, particularly those from the *Rubus fruticosus* aggregate or European blackberry, which has been recognised as a Weed of National Significance (WoNS).
- Since its introduction to Australia in the early 1830s, blackberry has spread throughout its climatic limits, covering more than 8.8 million hectares.
- Problems associated with blackberry include:
  - reducing the productivity of primary industries
  - degrading the natural environment and affecting biodiversity
  - restricting access to land and water
  - harbouring vermin
  - creating fire hazards.
- Blackberry provides benefits for fruit and honey production, as fodder for browsing animals, and as harbour and food for some native fauna species.

1.1 Blackberry in Australia

Blackberry, a plant belonging to the *Rubus* genus, is considered a significant weed in Australia because of the extent of its negative impacts. First introduced to Australia in the 1830s, *Rubus* species originating in Europe, North America and Asia have now become naturalised and infest over 8.8 million hectares of land from south-eastern Queensland to southern Tasmania and across to south-western Australia.

The *Rubus* genus comprises many different species of blackberry, including 10 that are native to Australia (which require protection), as well as raspberry species and cultivars such as dewberry (*R. roribaccus*) and loganberry (*R. loganobaccus*). The word 'blackberry' is often applied indiscriminately to refer to any of the variety of species.

Information in this manual relates to all known weedy *Rubus* species in Australia, particularly those from the *Rubus fruticosus* aggregate (*R. fruticosus* agg.), which have been recognised as Weeds of National Significance (WoNS) (see Figure 1.1).

The *R. fruticosus* agg. consists of hundreds of different named species in Europe. At least 16 of these species have been introduced into Australia (see Table 2.1, p. 20).

History in Australia

Species in the *R. fruticosus* agg. are among the most devastating weeds in southern Australia because of their invasiveness and their impact on productive land and natural ecosystems.

The R. fruticosus aggregate

Species from the *R. fruticosus* agg. were first brought to Australia by early settlers to include in gardens and hedgerows. An article in the *Bathurst Free Press* in 1851 reported that blackberry was planted in the Bathurst area in the 1830s. An article in the *Sydney Morning Herald* in 1851 also recorded blackberry growing in a Sydney garden.

Blackberry was grown to provide fruit for jams and pies. Records from a blackberry-picking enterprise in Bulli, New South Wales (NSW), document that four tonnes of fruit was sent to Sydney for manufacture into jams in 1894. By 1912, the amount of fruit sent had grown to 200 tonnes.

In 1851, the Government Botanist in Victoria, Baron von Mueller, and the first Curator of the Gardens at Melbourne University, Alexander Elliot, recommended that blackberry be planted to control soil erosion along creek banks. Nine species of blackberry were planted in Melbourne's Botanic Gardens.

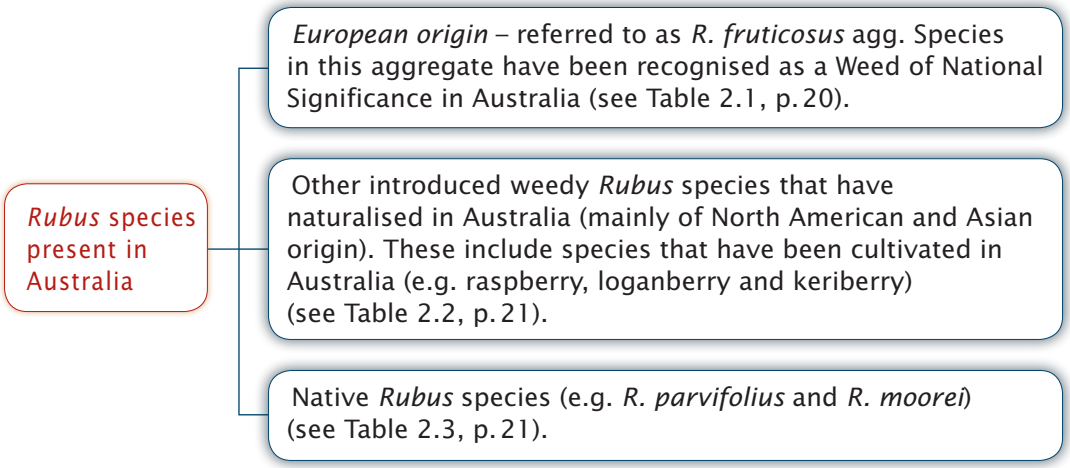


Figure 1.1: Overview of the genus *Rubus* in Australia.

In spite of the plant's recognised benefits, its potential weediness and associated problems were also quickly recognised. An article in the *Sydney Mail* in 1887 noted that 'blackberry planted for hedges was ruining farm land'. In 1906, landowners in the Armidale Protection Board area in NSW were encouraged to burn blackberry plants, as they harboured rabbits. Blackberry was declared noxious in parts of Victoria in 1894 and in the whole State in 1908.

See Appendix 1 for details of current noxious weed legislation concerning blackberry in all Australian States.

Other weedy Rubus species

The North American blackberry (e.g. *R. laudatus*) and keriberry (e.g. *R. rugosus*) species have spread from cultivated plants. These species have now become naturalised in Australia.

Penny Richards (DPI, Victoria)

Blackberry can dominate other vegetation.

Problems, benefits and costs of blackberry

Problems

Blackberry can infest a large area quickly. It grows vigorously; is prickly and able to propagate vegetatively from cane tips; effectively spreads seed through fruit-eating birds and mammals; and is relatively unpalatable to most livestock. The plant can also quickly smother other vegetation under a dense canopy. Once established, blackberry causes major problems, as listed below.

Reduced productivity of primary industries. Blackberry reduces the productivity of many primary industries, including grazing, cropping and forestry enterprises. Dense blackberry thickets shade out pastures and crops and compete for soil moisture and nutrients, effectively suppressing productive vegetation and reducing the stocking capacity of infested pastures.

In plantation forestry, blackberry can prevent the regeneration of natural hardwood forests and reduce the capacity of softwood and hardwood seedlings to establish and grow. The plant can also hinder forest operations, particularly in situations where infestations are heavy and walking access is required.

Penny Richards (DPI, Victoria)

Blackberry can affect the establishment of forestry seedlings.

Degradation of natural environments. Substantial displacement of native plants and loss of habitat for native animals is occurring in many environments invaded by blackberry. A report published by the Cooperative Research Centre for Australian Weed Management (CRC), 2006, identifies blackberry as the third most common weed threat in NSW, threatening 21 plant and animal species, as well as ecological communities.

Blackberry also affects the visual and recreational values of public land, parks and reserves. Blackberry infestations in natural landscapes can be aesthetically displeasing and detract from the appreciation of scenic views by visitors.

Restricted access to land and water. Blackberry can restrict stock access to pasture and water. When it grows densely along a watercourse, stock seeking water may be forced to constantly use the same tracks, and this can cause severe erosion. A combination of erosion and dense blackberry overgrowth of a stream can reduce water quality and flow.

Recreational restriction. Blackberry can restrict access to land for management purposes and recreational activities. For example, walking tracks may be obstructed, or access to streams by recreational fishers may be reduced.

A. McCaffery (NSW DPI)

An example of the uses of blackberry.

Harbour for vermin. Blackberry thickets provide harbour for vermin such as rabbits and foxes, introduced wildlife that threaten native flora and fauna. Blackberry fruit provides seasonal food for exotic animals such as starlings, blackbirds and foxes. The berries help to increase the population of these species, and the animals effectively disperse berry seeds in their scat, aiding in the spread of the weed.

Fire hazard. Dead blackberry material is a fire hazard. Blackberry infestations can also obstruct fire trails and access to water for controlling fires.

Benefits of blackberry

Fruit and honey production. Blackberry fruit is collected by many people and eaten fresh or used in cooking. The leaves can be used to make herbal teas, medicinal products for chest ailments, and astringents used in skin care. Beekeepers use blackberry flowers as a source of nectar for honey production.

Source of food. Browsing animals such as goats and deer can use blackberry as a source of food, and these animals are occasionally used to control the weed (see 'Grazing by goats and other livestock' in Part 4.2, p. 62). Many native and exotic birds also feed on blackberry fruit, especially when other food sources are not available.

Protection for native animals. A number of native animals and birds, such as bandicoots and blue wrens, use blackberry thickets as protection from predators and as a source of food.

The real costs of blackberry

The economic cost of blackberries as weeds in Australia is high. In 1984, the estimated annual aggregated cost across all Australian States and Territories of the *R. fruticosus* agg. alone was $42 million, and the annual aggregated benefit was $660,000. The cost figure excludes the social and biodiversity costs associated with blackberry infestations. Costs have risen considerably in recent years and in 2006 it was estimated that annual production losses and blackberry control costs are at least $70 million (CRC, 2006).

Distribution of current and potential infestations

Species in the *R. fruticosus* agg. infest about 8.8 million hectares of land in Australia (see Figure 1.2). They are considered weeds in all States and Territories except the Northern Territory. The aggregate is mostly restricted to temperate climates (warm summers, cool winters) with an annual rainfall of at least 700 millimetres. However, *R. fruticosus* agg. can grow in lower rainfall areas when other environmental conditions are favourable (e.g. along the banks of water bodies). It can occur at any altitude in Australia.

The *R. fruticosus* agg. has probably reached the climatic limits of its potential range in Australia in terms of rainfall and temperature. However, individual species within the aggregate may not have done so. Some species such as *R. anglocandicans* are widespread, whereas others are still limited in distribution. Although there may be minor differences in climatic and soil requirements among the species of the aggregate, each species probably has the potential to spread to the full climatic range of the *R. fruticosus* agg. in Australia (see Figure 1.3).

Table 2.2 (p. 21) lists the known distributions of other introduced blackberry species in Australia.

Climate modelling has been used to provide an example of areas in Australia that are likely to be suitable for blackberry under climate change (Steel *et al.*, 2008). This particular example predicts a change to the distribution of the *R. fruticosus* agg. as a result of climate change (see Figure 1.4, p. 14). It suggests that, overall, less of Australia will be suitable to the species, although some areas such as Tasmania and the alpine regions in south-east Australia will become more suitable.

As already noted, the potential for continued spread of each of the blackberry species is determined by its vigour, reproductive capacity and adaptability and the success of its seed-dispersal mechanisms. The blackberry leaf rust fungus (*Phragmidium violaceum*) is a biological control agent for blackberry. It inhibits the operation of the above factors and will potentially check the spread of susceptible blackberry species (see Part 4.3, p. 64). Species that are resistant to the fungus or grow in unfavourable climatic conditions for the rust are more likely to continue to spread.

Where blackberry is widespread, good planning and the implementation of appropriate control techniques can help landholders to reclaim or keep land free from infestation (see Parts 3, p. 28 and 4, p. 39).

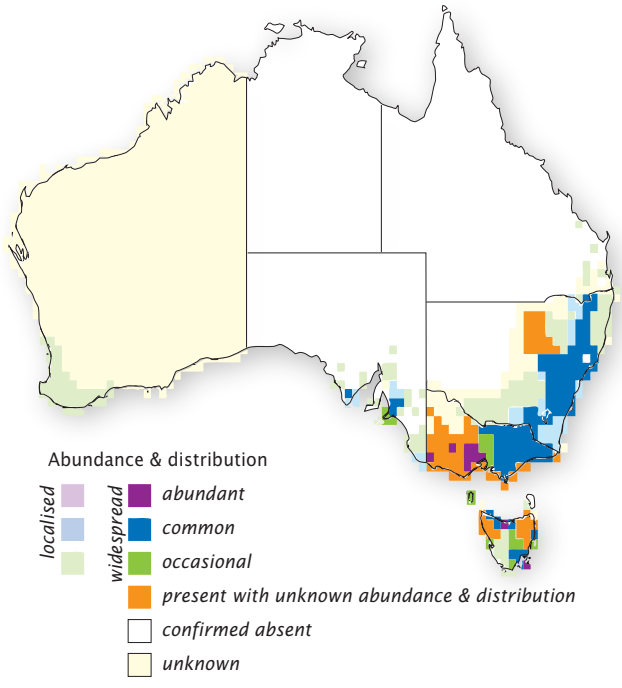


Figure 1.2: Current distribution of the *R. fruticosus* agg. in Australia

(Australian Government National Land and Water Resources Audit, 2008)

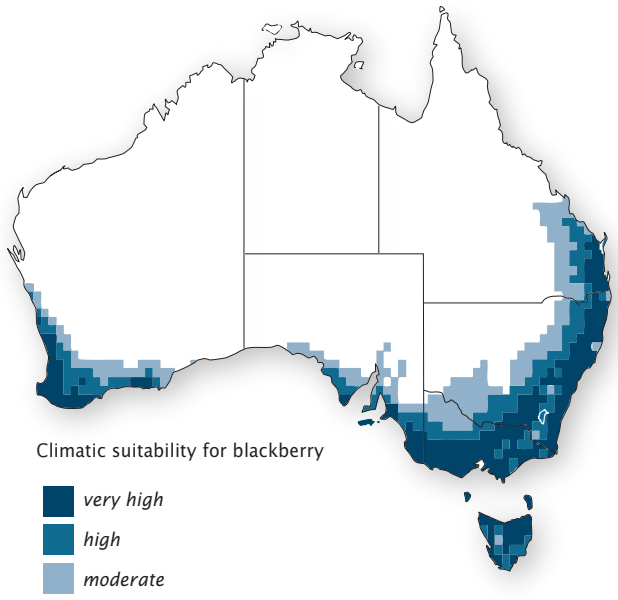
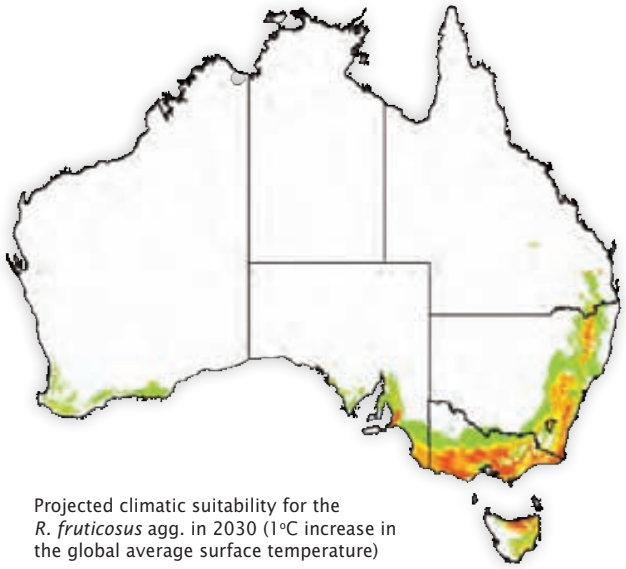
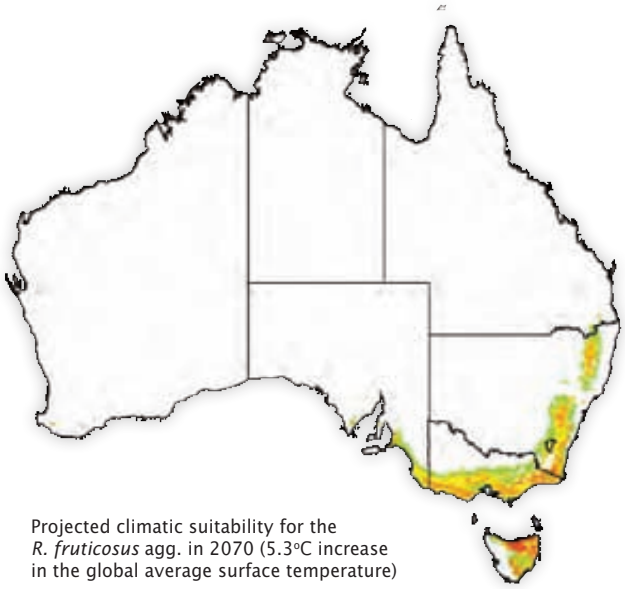


Figure 1.3: Potential distribution of the *R. fruticosus* agg. in Australia

(Department of Primary Industries, Victoria, 2008 derived using CLIMATE® modelling system)



Projected climatic suitability for the *R. fruticosus* agg. in 2030 (1°C increase in the global average surface temperature)



Projected climatic suitability for the *R. fruticosus* agg. in 2070 (5.3°C increase in the global average surface temperature)

Climatic suitability

- *high*
- *moderately high*
- *moderate*
- *likely*
- *not suitable*

Figure 1.4: Climate-change modelling for the *R. fruticosus* agg.

Steel et al., 2008.

The method used to produce these maps differs to that used to model the climate suitability for blackberry (see Figure 1.3, p. 13) so the results are not directly comparable. A detailed description can be found in the full report at www.climatechange.vic.gov.au (go to Resources/ Publications/*Climate change and potential distribution of weeds: whither the weeds under climate change?)*

Within blackberry's range, many areas that are currently free of the weed are under threat. Blackberry readily invades new areas, establishing itself on disturbed sites such as along access tracks, on freshly harvested forest lands, and in areas affected by fires and floods.

1.2 Description

Physical characteristics

Physical features vary between the three groups of *Rubus* species in Australia (see Figure 1.1, p. 10). Those within the *R. fruticosus* agg. are similar in appearance and difficult to distinguish. Their key features are outlined below. However, the other introduced and native *Rubus* species vary in many details, including leaf shape, flower and fruit colour. Part 2 (p. 20) provides more detailed taxonomic information to help identify individual *Rubus* species.

Rubus fruticosus agg. species are perennial, semi-deciduous, scrambling shrubs. The tangled prickly stems (canes) form impenetrable thickets several metres high. Species reproduce vegetatively and from seed.

Root system

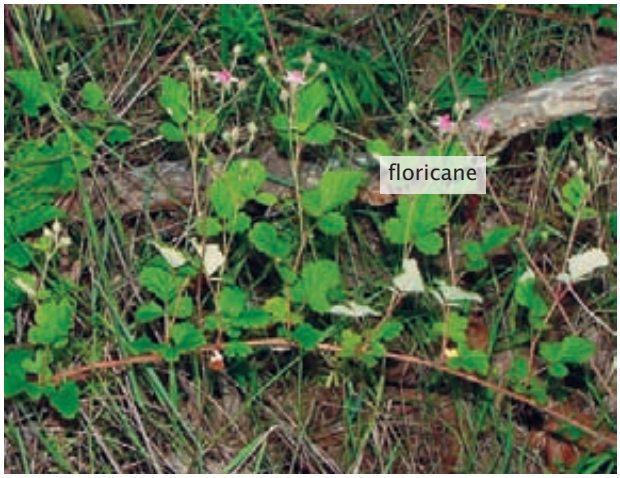
The root system is the only perennial part of the plant. It comprises a woody crown that can grow up to 20 centimetres in diameter and a main root that can grow down to four metres, depending on the soil type. Numerous secondary roots grow horizontally from the crown for 30–60 centimetres. These secondary roots then also grow down and further shoot thin roots in all directions.

Stems or canes

The stems (canes) are erect or semi-erect, arched or trailing, and grow up to seven metres long. With the exception of one species (*R. ulmifolius* var. *anoplothyrsus*) they are covered in sharp prickles. Canes are generally biennial but may occasionally live longer. Canes may be green, purplish or red, depending on their exposure to light.

Birgitte Verbeek (NSW DPI)

Example of a European blackberry primocane.



Birgitte Verbeek (NSW DPI)

Example of native blackberry floricane.

Leaves

Rubus fruticosus agg. species leaves are usually dark green on top with a lighter green underside. Leaves are compound, with three to five leaflets and are palmate (see Part 2.2, p. 22). The leaflet veins and stalks are covered with short, curved prickles. Leaves arise alternately along the canes, and most are shed during winter, except in warmer climates where leaves may be retained.

Birgitte Verbeek (NSW DPI)

Leaves are dark green on top with a lighter green underside.

Auld and Medd (NSW DPI)

A typical *R. fruticosus* agg. blackberry shrub.

Flowers

The flowers are white or pink and 2 – 3 centimetres in diameter. They occur in clusters at the end of floricanes (second-year canes that bear fruit). The clusters of flowers form either a cylinder or a pyramid, depending on the species. Flowers may change colour between bud and opening, depending on the species. Flowering occurs from late November to late February in *R. fruticosus* agg. species (see Table 1.1, p. 17).

Birgitte Verbeek (NSW DPI)

European blackberry (*R. anglocandicans*) flowers.

Fruit

The fruit is a 1–3 centimetre diameter berry, which changes colour from green to red to black as it ripens. Each berry consists of a number of fleshy segments (drupelets). Each drupelet contains one seed. Fruit are found from late December to April (see Table 1.1, p. 17).

Alyssa Schembri (NSW DPI)

Fruit from a species in the *R. fruticosus* agg.

Seeds

The seeds are light to dark brown, oval, 2–3 millimetres long, and deeply and irregularly pitted.

1.3 Lifecycle, reproduction and spread

The information in this part refers predominantly to blackberry in the *R. fruticosus* agg. There is little information available on the lifecycles and spread of other introduced blackberry species under Australian conditions.

As with all blackberry, species in the *R. fruticosus* agg. can reproduce vegetatively and by seed. Germination of seed occurs from September through to December (see Table 1.1, p. 17). Each berry may contain from 20–30 seeds. Up to 13,000 seeds/m^2 can be found under a blackberry bush. Plants in dense shade will produce fewer seeds than those in open areas. Seedling survival rate is considerably lower in shaded areas than in full sun.

Seeds are spread over long distances by birds, mammals (including foxes and humans), water and contaminated soil.

Reproduction by seed

Only one of the species of the *R. fruticosus* agg. species found in Australia (*R. ulmifolius*) produces seed sexually. The other species produce seed by pseudogamy: the pollen grain stimulates the egg cell (ovum) but there is no fertilisation. The seed produced is an exact duplicate of the mother plant – a clone. There is no clear evidence of hybridisation between species in Australia, but, if it occurs, one of the parents is likely to be the sexually reproducing *R. ulmifolius*. Any resulting hybrids would then be able to reproduce true-to-type by pseudogamy.

Vegetative reproduction

In vegetative reproduction, young canes emerge from buds on the crown each spring and grow very rapidly (5–8 cm/day). These first-year canes (primocanes) grow in either a prostrate or an arching manner. In autumn the tips of the arching primocanes may touch the ground, sprout roots and become new plants. These new plants, called 'daughter plants', will produce a primocane in the following spring (see Figure 1.5, p. 17).

Axillary buds on second-year primocanes sprout in spring producing short canes (floricanes) that terminate in a panicle (branched cluster) of flowers. Only two-year-old primocanes produce floricanes with flowers and fruit (see Figure 1.5, p. 17).

After producing floricanes in the second year, the primocane usually dies back to the crown over autumn and winter and does not regenerate. In rare cases the primocane will last into a third year. If a daughter plant has developed on the tip of the primocane it will continue as an independent plant.

Rubus fruticosus agg. species can also reproduce from root fragments and other plant parts if transported to a new area, for example by floodwaters.

Table 1.1: Lifecycle of the *R. fruticosus* agg. in temperate southern Australia.

	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
	WINTER			SPRING			SUMMER			AUTUMN		
Germination				■	■	■	▒					
Flowering (2-y-o)						▒	■	■	▒			
Fruiting (2-y-o)							▒	■	■	▒	▒	▒
Tip rooting (1-y-o)	▒	▒								■	■	■
Dormancy	■	■	■									

Dark shading indicates most common timeframe for stage of life cycle. However, each stage can still occur during the lighter shaded periods.

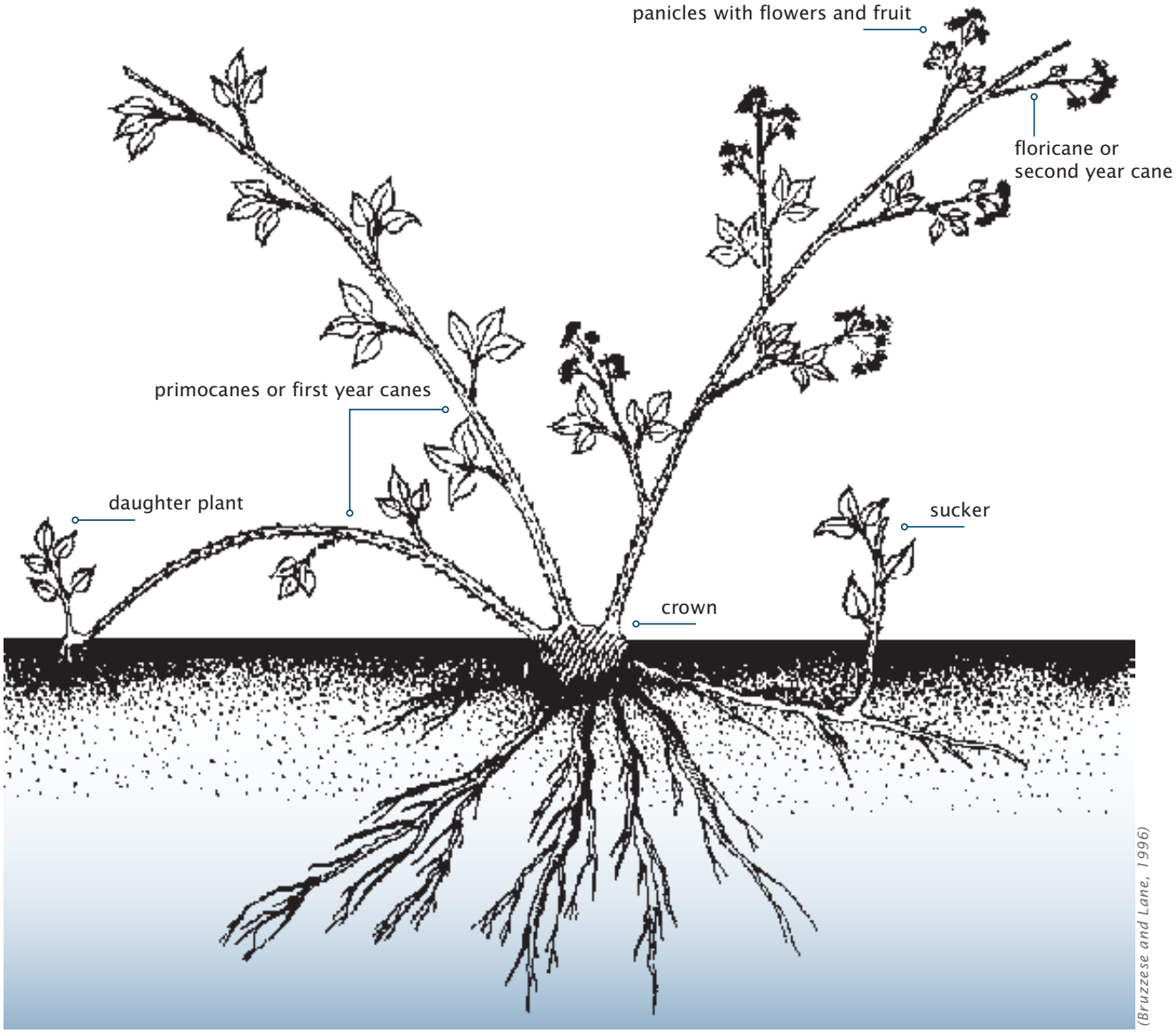


Figure 1.5: Growth pattern of *R. fruticosus* agg. species.

Case study

Impact of blackberry

The problem

Cattle, horses and pigs introduced blackberry into the upper reaches of the Kowmung River from nearby farms in the 1800s. Blackberry infestations gradually spread along the river as stock moved further into the leased catchment lands.

In 1975 the Kowmung catchment became part of the Kanangra-Boyd and Blue Mountains National Park. Stock were removed from the area, but it was not possible to remove those that had become feral.

Both the feral animals and the blackberry infestations compromise the significant natural, recreational and economic values of the region. In 1997 the NSW National Parks and Wildlife Service (NPWS) began to implement a management plan to control blackberry and the feral animals.

Impacts of blackberry

- *Competition.* With few natural controls, blackberry quickly colonised disturbed areas along the river, outcompeting native species. In the Kowmung River corridor, the main causes of disturbed ground are fires, floods and feral pigs.
- *Safe harbour.* Blackberries provide harbour for feral pigs, making it harder to undertake aerial culling. The thickets also protect young pigs from wild dogs, which would otherwise help control pig numbers.

Mikala Jones (NPWS)

The Kowmung River is extremely inaccessible and had to be accessed and treated on horseback.

- *Recreational values.* Walkers along the Kowmung River expect to find riverbanks and flats in their natural state. However, blackberry thickets make walking difficult, reduce the number of camping spots and compromise the wilderness experience.
- *Downstream impacts.* As blackberry infestations gradually move downstream, their impact on natural and recreational values grows. The weed does not confine itself to the river but spreads up side gullies into once pristine sub-catchments.

What has been done?

Initially, NPWS staff and contractors concentrated their blackberry control efforts on infestations located along the riverbanks. Because the catchment is relatively inaccessible, they set up remote base camps for several weeks each year, targeting a 15 kilometre stretch of river. They use 12-volt electric pumps mounted on pack horses to apply herbicide to blackberry thickets – an effective technique, because the added height of the pumps allows the spray to reach the top and middle of the largest thickets.

In the upper reaches of the river and its smaller sub-catchments, NPWS staff sprayed infestations annually using vehicle-mounted spray units and splatter guns.

By 2005, infestations along the river had been significantly reduced and attention turned to controlling upstream sources of blackberry, mostly on private property.

The result

When the blackberry control program started, infestations along the river ranged from the occasional individual blackberry bush to thickets that were five metres high and covered over 300 m^2. As a result of the NPWS programs there are:

- no remaining large blackberry infestations.
- the number of pig harbours has significantly decreased.
- pig disturbance along the river is noticeably less, and flats once infested with blackberry are gradually regenerating with native vegetation.
- NPWS staff, contractors, bushwalkers and volunteers report that the recreational wilderness values of the riverine corridor have been enhanced.

Part 2

Identification of blackberry (*Rubus*) species in Australia

Summary

- There are 26 known introduced *Rubus* species in Australia. Sixteen of these are from the *R. fruticosus* agg. (European blackberry). The other 10 are classed as other introduced weedy *Rubus* species and originate from either North America or Asia.
- There are also 10 native *Rubus* species present in Australia.
- It is difficult to distinguish between the species in the *R. fruticosus* agg. Land managers should send samples to a herbarium for positive identification.
- An interactive computer key on CD-ROM has been developed to help identify the various blackberry species in Australia (see Part 2.2, p. 22).
- Features such as leaf shape and the inflorescence are used to distinguish between species in the *R. fruticosus* agg. and other *Rubus* species (introduced and native) in Australia.
- Identifying the correct species will help to determine and implement the most effective control options.

2.1 The genus *Rubus* in Australia

There are three main groups of blackberry present in Australia:

- *The R. fruticosus* agg. or *European blackberry*. There are currently 16 known species of this aggregate in Australia (see Table 2.1). They are recognised as a Weed of National Significance (WoNS) in Australia and are declared noxious in most Australian States and Territories (see Appendix 1).
- *Other introduced weedy* Rubus *species that have become naturalised in Australia* (see Table 2.2, p.21). This group includes *Rubus* species from North America and Asia. Many of the introduced species, such as raspberry and loganberry, are also commonly cultivated.
- *Native* Rubus *species*. There are 10 known native species of *Rubus* in Australia (see Table 2.3, p.21).

The taxonomy of blackberry in Australia was recently reviewed. With the help of the weed management community, 300 new herbarium samples were collected from the southern States of Australia. The physical characteristics of existing and new samples were studied and the DNA extracted from each to determine their genetic relationships. Selected specimens were then sent to Europe and America for identification by experts in *Rubus* taxonomy.

This work has improved species identification and has provided more information on the distribution of species, enabling the development of an interactive computer key on CD-ROM (Barker and Barker, 2005) to help identify the various blackberry species (see Part 2.2, p.22).

When exotic plants (i.e. plants foreign to an area) have been introduced to a new area and become established and spread, they are considered to have become naturalised in that area.

Table 2.1. European blackberry (*R. fruticosus* agg.) in Australia (2007)

SPECIES	DISTRIBUTION AND ORIGIN
R. anglocandicans	Most commonly recorded species in southern Australia. It occurs in the wetter areas of all the southern States and south-eastern Qld.
R. leucostachys	Widespread distribution. Recorded in NSW, Vic., Tas. and SA.
R. polyanthemus	Widespread in Vic. Recorded in Kosciusko National Park, NSW.
R. laciniatus	Recorded in the wetter areas of NSW and SA. Also recorded on the central-west coast of Tas.
R. ulmifolius* var. *ulmifolius	Recorded in all southern States of Australia.
R. ulmifolius* var. *anoplothyrsus	Recorded in SA and WA. Possibly present in other States. No prickles on primocanes.
R. vestitus	Recorded in NSW, SA and Tas. but not common.
R. leightonii	Recorded only in NSW.
R. erythrops	Recorded in Vic., Tas. and SA.
R. cissburiensis	Recorded only in Vic.
R. echinatus	Mostly recorded in north-eastern Tas. Also recorded in Vic. and Flinders Island.
R. rubritinctus	Recorded in the Mt Lofty Ranges of SA and Geeveston and Pipers Brook in Tas.
R. phaeocarpus	Limited distribution. Recorded in the Mt Lofty Ranges in SA and in the Kowmung River area of NSW.
R. riddelsdellii	Recorded only in the Mt Lofty Ranges of SA.
***R.* sp. Tasmania** (J.R. Hosking 1551)	Confined to Tas., predominantly in the north-western region.
***R.* sp. Scott Creek** D.E. Symon 16054)	Recorded only in the Mt Lofty Ranges of SA.

Barker and Barker, 2005

Table 2.2. Other introduced *Rubus* species in Australia (2007)

SPECIES	DISTRIBUTION AND ORIGIN
R. laudatus **(Bundy/Plains blackberry)**	Commonly recorded as a weed in south-west WA, south-eastern Qld and throughout the Sydney area of NSW. Originating from North America.
R. philadelphicus **(lawtonberry)**	Recorded as a weed in Pipers Creek area of northern Tas. and in Cooma in south-eastern NSW. Originating from North America.
R. loganobaccus **(loganberry)**	Recorded as a weed in south-western WA across the mid-north region of SA, on Kangaroo Island, in the Canberra region, in the Ballarat area of Vic. and in southern-eastern Tas. A hybrid between North American *R. ursinus* and Eurasian *R. idaeus*. Can be distinguished by its pinnate leaves and its oblong fruit, which is dark red to dull black.
R. ellipticus **(yellow Himalayan raspberry)**	Recorded as a noxious weed in south-eastern Qld. Also found in the north-eastern and Blue Mountains regions of NSW. Originating from Asia. Easily distinguished by its yellow to orange fruit.
R. idaeus **(raspberry)**	Cultivated in the cooler region of the southern States. Originating from Eurasia; sometimes also considered to be native to North America. Naturalised populations recorded in NSW, Vic. and SA. Not considered to be aggressively weedy. Has red fruit.
R. rugosus **(keriberry)**	Grown in NSW and Qld for its fruit. Originating from Asia. Naturalised populations recorded in the Comboyne area of NSW and the Belgrave South area of Vic. At this time it is not aggressively weedy. Also recorded in small numbers in WA and Tas.
R. roribaccus **(dewberry, youngberry and boysenberry)**	Naturalised populations recorded in the Central Coast and Sydney regions of NSW. Also recorded in the Portland region of western Vic. Originating from Northern America. At this stage it is not aggressively weedy.
R. alceifolius	Recorded in the Cape Tribulation region of Qld. Originating from Asia and a weed in many parts of the world.
R. odoratus	Often cultivated for its large, scented, pink-purple rose-like flowers. Not recorded with any confidence as naturalised in Australia, despite the possible record from Hobart in Tas.
R. niveus	Only recently (2008) recorded as naturalised in Australia; found in Qld and the on the North Coast of NSW. Originating from Asia, and considered a weed in other parts of the world. Also grown for its sweet fruit. Flowers are pink to rose purple.

Barker and Barker, 2005; Evans et al., 2007

Table 2.3. Native *Rubus* species in Australia (2007).

SPECIES	DISTRIBUTION AND ORIGIN
R. parvifolius **(native raspberry)**	The most widely distributed native species of *Rubus* in Australia. Extends from central Qld, along the east coast to Vic. and Tas. along the coastline to the Mt Lofty Ranges in SA. Often occurs with the *R. fruticosus* agg.
R. gunnianus **Hook. (alpine Tasmania)**	A Tasmanian endemic species that occurs in alpine vegetation. It is very small and easily distinguishable from introduced *Rubus* species.
R. moorei **(silky bramble)**	Generally confined in distribution from Lismore in NSW to the Conondale Ranges in Qld.
R. rosifolius	Found along the eastern coast of Australia, from south-eastern Qld through to Vic.
R. queenslandicus	An endemic north Qld species from the Atherton Tableland region.
R. probus	A species confined to coastal areas of Qld between Daintree and Brisbane.
R. x novus	An apparently sterile hybrid between *R. moluccanus* var. *trilobus* and *R. parvifolius*. This hybrid occurs naturally and is found along the east coast of Australia where both species occur.

SPECIES	DISTRIBUTION AND ORIGIN
R. moluccanus* var. *moluccanus	Found along the east coast of Australia from the McIlwraith Range to the Moreton Bay district.
R. moluccanus* var. *trilobus	Found along the east coast of Australia from the Atherton Tableland to north-eastern Vic. More commonly encountered than *R. moluccanus* var. *moluccanus*.
R. nebulosus	An east coast species extending from the NSW–Qld border to Batemans Bay on the South Coast of NSW. Flowers from August to January and is found in rainforests or tall eucalyptus forests next to rainforests.

Barker and Barker, 2005

2.2 Identifying species

Distinguishing among species in the *R. fruticosus* agg.

The best way to ensure correct identification of blackberry species is to send samples to a herbarium for positive identification. The best time to collect samples is when the plant is flowering. Segments of both the floricane and primocane are needed to identify *Rubus* specimens to species level.

If possible, collect three separate specimens from the one plant. Keep one for personal reference and send two to the herbarium. The herbarium receiving your specimen can then forward one to the main *Rubus* collection, located at the State Herbarium of South Australia, in Adelaide for verification. Appendix 2 provides detailed guidelines on collecting samples for identification. Appendix 3 lists contact details for State herbaria.

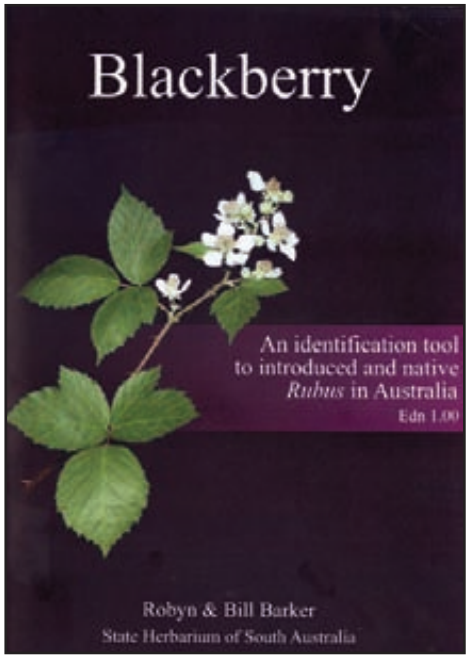
Alternatively, the interactive identification key on the CD-ROM, *Blackberry, an identification tool to introduced and native* Rubus *in Australia*, is a useful resource. It is available for purchase from **www.cbit.uq.edu.au/software/blackberry/** See Appendix 4 for the fact sheet on using the CD-ROM Lucid Key.

Even with the development of the key contained in the CD-ROM and other identification resources, it requires specialist skill to distinguish between some of the species. It is therefore important that blackberry managers help to accumulate information about species presence and distribution across Australia by sending samples to a herbarium for positive identification and mapping.

Importance of identifying blackberry species

Different *Rubus* species react differently to various control options such as herbicides or biological control agents. For example, species originating from North America or Asia are not susceptible to the current biological control options available in Australia. As a consequence, where infestations are made up of mixed species, a species that has been controlled with biological control or herbicides can be replaced by a species with a higher tolerance to these control options.

It is also important to know whether the blackberry in question is a native species. Native blackberry species should not be controlled in their native range.



Robyn Barker (Department for Environment and Heritage, SA)

Blackberry identification tool Lucid CD.

Distinguishing between *R. fruticosus* agg. and species of North American and other origin

Three North American *Rubus* species have become naturalised and weedy in Australia. They are *R. laudatus* (Bundy/Plains blackberry), *R. philadelphicus* (lawtonberry) and *R. roribaccus* (dewberry). They can be distinguished from the *R. fruticosus* agg. species by the characteristics given in Table 2.4 (p. 24).

Figure 2.1 (p. 24) shows the differences in the inflorescences (flower clusters) and pedicels (flower stalks). Figure 2.2 (p. 24) shows differences in the sepals and Figure 2.3 (p. 25) shows differences in the leaf characteristics.

Rubus loganobaccus (loganberry) is a stabilised hybrid of *R. idaeus* (European) and *R. ursinus* (North America). It can be distinguished from *R. fruticosus* agg. species by its pinnate leaves.

Species in the *R. fruticosus* agg. have palmate leaves. Figure 2.3 (p. 25) shows the various leaf shapes and leaflet arrangements.

Rubus idaeus (raspberry) is widely cultivated and is considered weedy. Apart from being distinguished by its hollow red or yellow fruit, it also has pinnate leaves. *R. fruticosus* agg. species have black fruit and palmate leaves.

Rubus ellipticus (yellow Himalayan raspberry) has been declared noxious in Queensland. It has soft bristles on the stems, rounded leaflets and yellow-orange fruit.

Rubus alceifolius and *R. rugosus* are of Asian origin and have simple lobed leaves (see Figure 2.3, p. 25) and red fruit at maturity.

Rubus niveus (Ceylon raspberry) has only recently been recorded in northern NSW and has also been found in Queensland. It has pinnate leaves that appear dark green on top and whitish below. The fruit is purple–black at maturity.

Paul Yeoh (CSIRO Entomology)

R. laudatus (Bundy/Plains blackberry) in Western Australia.

John Hosking (NSW DPI)

R. leucostachys in Kosciusko National Park.

R. J. Hore (Victoria)

R. rugosus (keriberry).

Craig Stehn (Coffs Harbour Regional Landcare)

R. niveus (Ceylon raspberry).

Table 2.4. Summary of features distinguishing between *R. fruticosus* agg. (European origin) and North American *Rubus* species.

	EUROPEAN ORIGIN *R. fruticosus* agg.	NORTH AMERICAN *Rubus* SPECIES
Inflorescence (collection of flowers at the apex of the floricane)	In panicles (branched flower head) – Figure 2.1(A)	Not in panicles – Figure 2.1(B)
Pedicel (flower stalk) length	Mostly less than 1.5 cm – Figure 2.1(C)	Mostly more than 1.5 cm – Figure 2.1(D)
Sessile (non-stalked) glands on primocane	No sessile glands	With sessile glands
Sepals (in fruit)	Reflexed, bent backwards from the fruit – Fig 2.2	Not reflexed, surrounding the base of the fruit – Fig 2.2

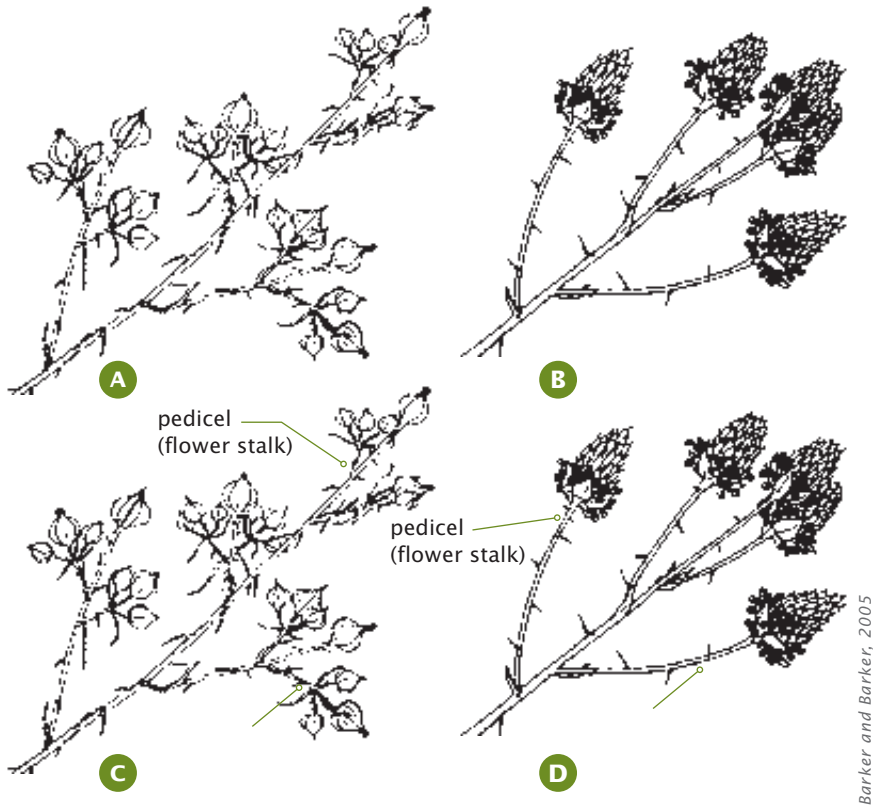


Figure 2.1 Inflorescence and pedicel length (see Table 2.4 for key).

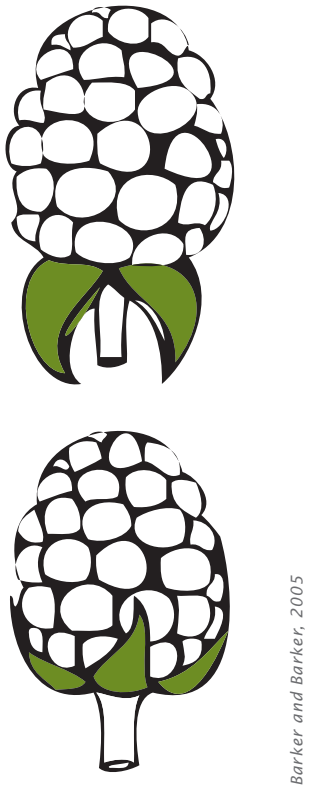


Figure 2.2 Sepals reflexed (above) or non-reflexed (below).

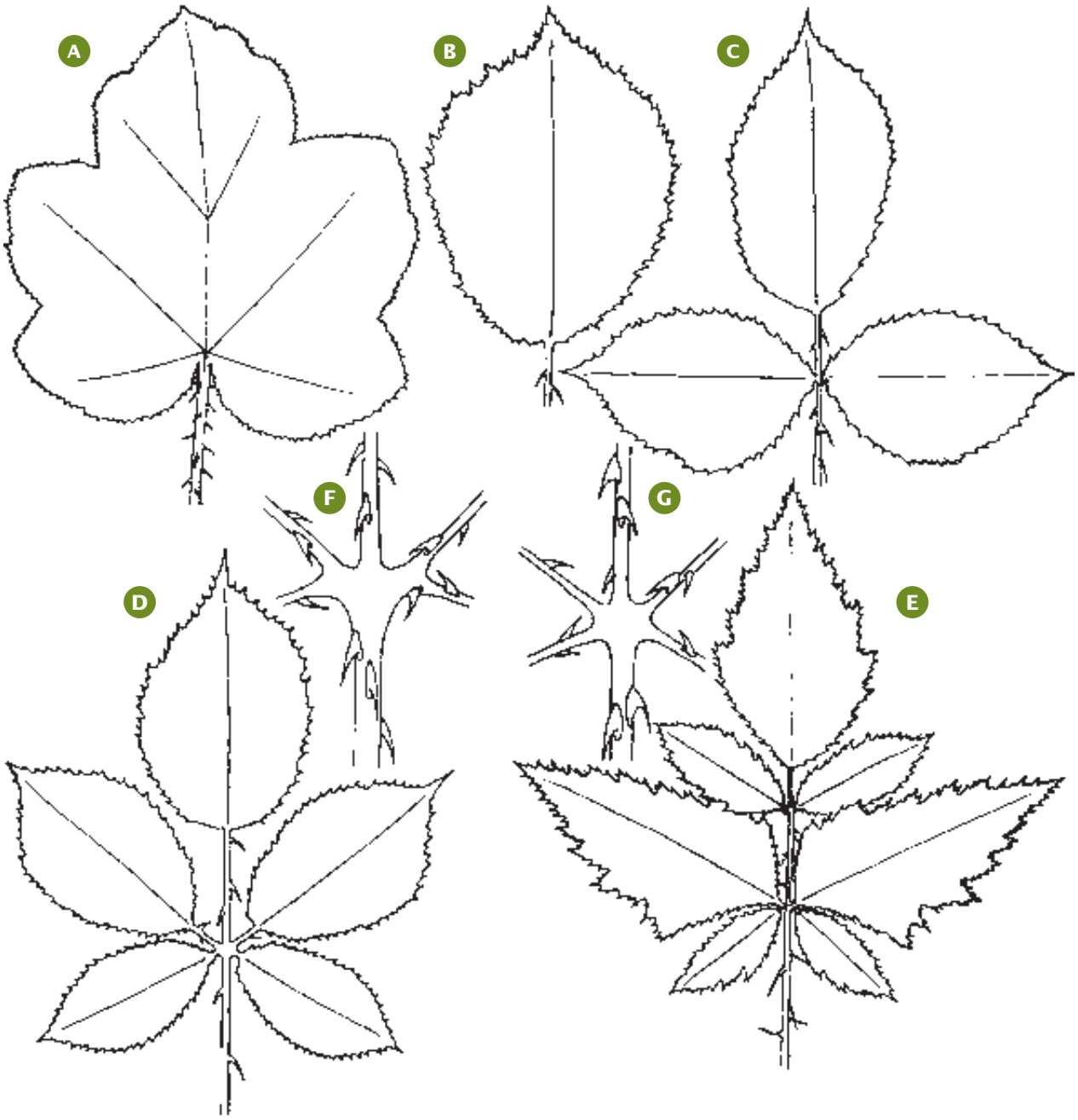


Figure 2.3 Leaf characteristics of *R. fruticosus* agg. and North American *Rubus* species in Australia. *Drawing by Beth Chandler from Evans et al., 2007*

A–entire lobed leaf as found in *R. rugosus*.

B–simple (reduced trifoliate) leaf found in the upper parts of the floricane in many taxa of the *R. fruticosus* agg.

C–typical leaf found subtending base of most inflorescences in the *R. fruticosus* agg.

D–typical leaf found in taxa of the *R. fruticosus* agg.

E–pinnate leaf as found in *R. loganobaccus*, *R. idaeus* or *R. parvifolius*.

F–pedate arrangement of petiolules where the lowest pair of petiolules arises from the middle pair of petiolules as found in *R. leucostachys* or *R. riddelsdelli*.

G–digitate arrangement of petiolules where the petiolules of all leaflets arise from the same point on the petiole, for example, *R. anglocandicans*.

Distinguishing native *Rubus* species

The native *R. parvifolius* is the most commonly encountered and widely distributed native *Rubus* in Australia. It is often found growing with other *Rubus* species in infestations and is easily distinguished by its pinnate leaves and distinctive pink to red flowers.

Table 2.3 (p. 21) lists the *Rubus* species native to Australia.

Birgitte Verbeek (NSW DPI)

Birgitte Verbeek (NSW DPI)

*R. parvifolius (*Native raspberry).

Case study

Importance of blackberry identification

At Tumut Shire Council in southern NSW the Noxious Weeds Inspector was informed by Forests NSW that they had a problem with the control of certain blackberries near a creek line. The inspector noted that this blackberry had a slightly different appearance to others he had been controlling in the region.

When he had the species identified at a herbarium, it was found to be *R. philadelphicus*, a blackberry species from North America that grows readily in any type of soil as long as there is consistent moisture. Unlike other blackberry species in this area, it could not be controlled with Brush Off® (metasulfuron) but seemed to die back well when treated with Grazon Extra® (containing a mixture of the active ingredients triclopyr, picloram and aminopyralid).

Part 3

Developing a blackberry management plan

Summary

- The first step when developing a blackberry management plan is to assess, record and map the features of the blackberry infestation.
- Use information from site assessments to identify priority areas for treatment.
- The prioritisation process is the basis for setting goals that are realistic, have clear timeframes and can be measured. Often it is useful to have both short-term and long-term goals.
- It is important to collate all the assessment and priority information into a blackberry management plan.
- Monitor outcomes and adjust the plan if necessary.
- Retreatment and rehabilitation are important to achieve ongoing control of blackberry infestations.

3.1 Developing a management plan

This section explains the five steps (see Figure 3.1) a land manager should take when developing a plan for managing blackberries:

1. Assess the problem.
2. Prioritise the areas for management within the infestation.
3. Set realistic and measurable goals.
4. Prepare, document and implement an integrated management plan.
5. Monitor, record, retreat and rehabilitate.

The first three of these steps are probably the most complex and time consuming. However, if they are carried out well, they will help to ensure that the plan is successful.

Case study

The importance of site assessment

The importance of assessing an infestation thoroughly and using the information to identify the challenges that come with treating an area has played an important role in the management of blackberry in the Hunter Region of NSW.

Land managers in the region are often faced with controlling blackberry in relatively inaccessible areas, such as the sides of steep hills and in watercourses. This places limitations on the use of conventional management techniques and equipment, because many of the sites are accessible only on foot or horseback. In addition, spray drift, which affect water quality, is an important consideration.

Identifying these issues early in the management planning phase allowed the development of a blackberry management program that utilises specialised equipment in the form of splatter guns (see Case study 'Use of the splatter gun' p. 54) to address these issues and achieve the best results.

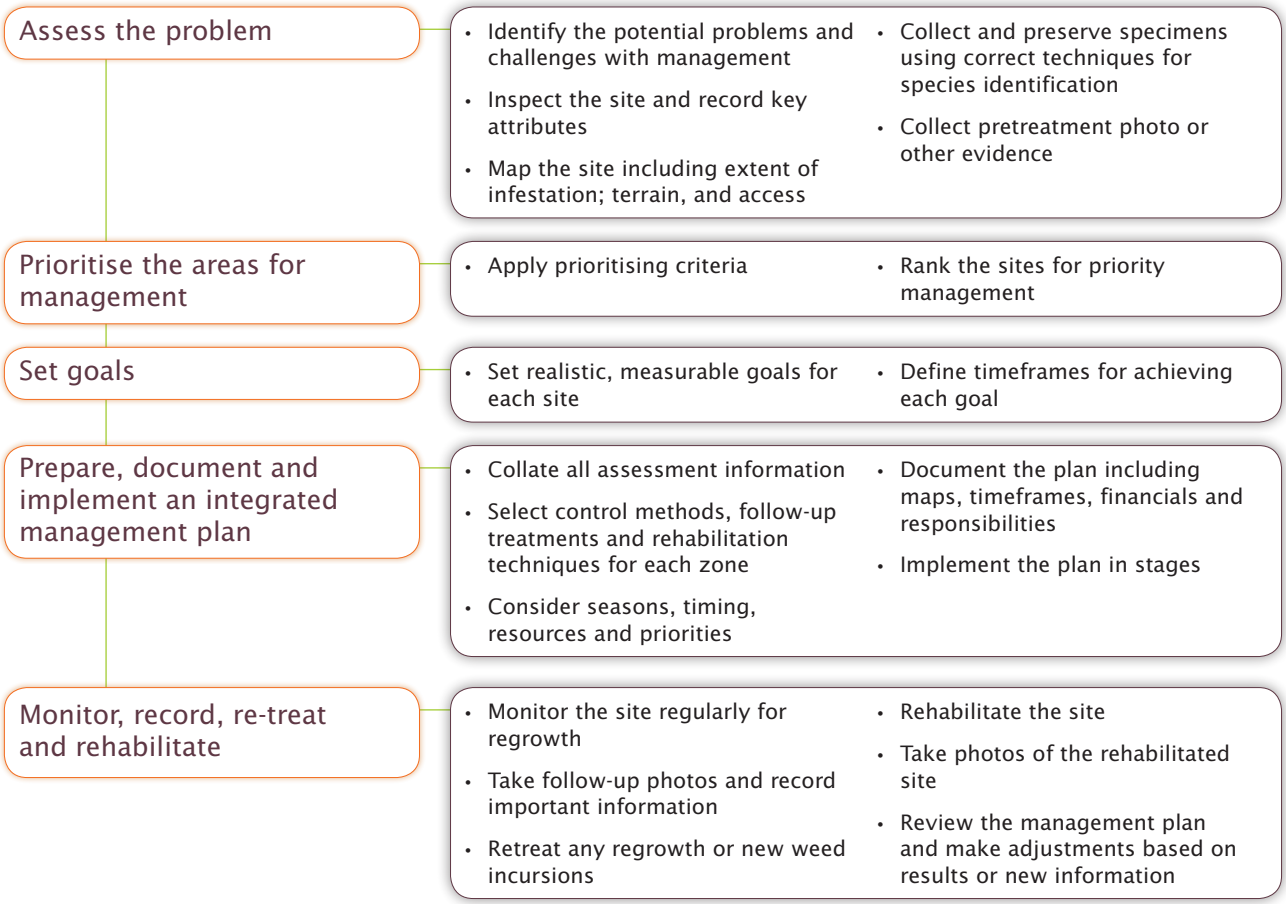


Figure 3.1: Overview of the site assessment and prioritisation process.

Penny Richards (DPI, Victoria)

Some sites may be difficult to access.

3.2 Assess the problem

By assessing the nature of a blackberry infestation, the land manager gathers data that can be used to develop the blackberry management plan. The assessment process is a systematic way of: recording the type of land infested by blackberries and the size of the infestation; the resources available to the land manager; and the characteristics of the area. All these factors will influence the choice of control strategies.

The site assessment process is summarised in Figure 3.1 (p. 28).

Case study

A community approach to developing a blackberry management plan

Taken from the Victorian Landcare and Catchment Management Newsletter.

Initiated by local farmers, the North East Blackberry Action Group was formed in 2005 to represent 16 private and public land management organisations dealing with the spread of blackberry in the Upper Murray catchment in Victoria.

The group has had many achievements over the three years of its operation, including gaining a substantial amount of funding from a number of grant programs. This enabled the group to engage a project manager to coordinate the project. The project manager liaised with over 70 landholders to negotiate three-year blackberry management agreements. Over 3100 hectares of land have now been mapped and are under management agreements.

Many land managers in the area claim that the project has been the most successful weed management program in the area in the last 20 years.

Group chairperson Lyn Coulston attributes the group's success to its initial planning efforts and the commitment of the partner organisations.

Lyn explained:

Before we started we had a couple of sessions to come up with an action plan. This means all the partners have ownership of the project and there were no unrealistic expectations about what we were trying to achieve. There is a benefit to the whole community if we can identify the barriers to successful control programs and work better with landholders to find ways of achieving better management practices.

A documentary has been made about the group and its processes. It is available through the Victorian Blackberry Taskforce website at **www.vicblackberrytaskforce.com.au/news/**

Michael Reid (DPI, Victoria)

The North East Blackberry Action Group project in the Upper Murray has resulted in effective management of blackberry infestations in the area.

1. *Identify the problems associated with the infestation*. The land manager should start the assessment process by listing the range of problems the blackberry infestation is causing. These will differ, depending on whether the land is used for productive purposes or set aside for amenity or natural ecosystem values.
2. *Determine the potential problems associated with managing the infestation.* To ensure that the process of controlling a blackberry infestation does not create another set of problems, consider issues that might arise as a result of undertaking a blackberry control program. For example, will the removal of blackberry increase erosion or remove essential habitat for native animals, or will the use of herbicides affect other producers (such as organic farmers) or the environment? (Part 4.1, p. 39 has more information on this.)
3. *Consider the potential challenges associated with the management of blackberry* (see *Questions to ask to expose potential challenges*).
4. *Inspect the site and record key attributes*. This step provides the data to both plan appropriate management programs and monitor whether the program is being effective. Appendix 5 is an example of a record sheet.

   When filling out the record sheet, use a map to note features and characteristics about the infestation that could influence the management program. This will provide a visual perspective on the relevant issues.

   Use a map that is most appropriate to the type of infestation being considered. Infestations on a single property can be mapped directly onto a property map, such as a property management plan.

Types of problems caused by blackberry infestations

Land used for production

- Competition with pastures and crops for light, moisture and nutrients.
- Restricted access to land.
- Habitat for vermin such as rabbits and foxes.
- Restricted stock access to pasture and water.
- Competition with amenity tree plantings.
- Fire hazard.
- Reduced road safety.
- Spread to another property, public land or high-conservation-value areas.

Natural ecosystems and amenity areas

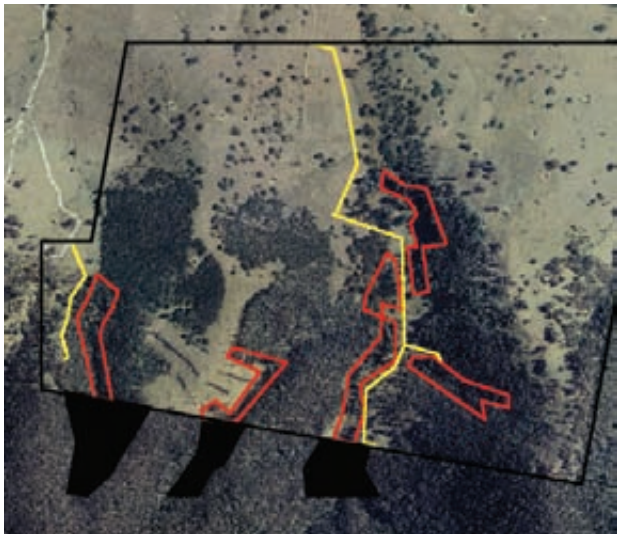
- Degradation of habitats.
- Threat to adjoining land, including agricultural enterprises and areas of high biodiversity value.
- Restricted access to land or waterways for management purposes (e.g. fire trails) or recreation (e.g. bushwalking, fishing/angling).
- Increased bushfire risk (blackberry thickets increase fuel load).
- Habitat for vermin that may affect native species.

Questions to ask to expose potential challenges

- Will there be conflict between land use priorities (e.g. recreational purposes versus conservation objectives)?
- What is the potential for success considering the availability of labour and equipment, blackberry density, accessibility of the site, adequate funding and available resources for follow-up monitoring, treatment and rehabilitation?
- Is there an opportunity to coordinate with other conservation programs or community-group work to enhance the conservation values of the area or to protect private land?
- What are the community expectations for weed management at high-profile sites? The cost of managing blackberry on roadsides, railway corridors, utility easements and neglected areas can outweigh the financial benefits, except where it is for fire prevention under power lines or along access tracks and to prevent sources of infestation of adjoining land.
- Is there a requirement for public thoroughfare?
- Are there boundary disputes between landholders, public land managers and local government?

A topographic map of the appropriate scale may also be useful, especially if it shows access tracks, roads, boundaries and the uses of land adjoining the infestation(s).

Infestations to be managed on a catchment scale need to be identified on regional maps that show the distribution of infestations over a wide area. Such mapping exercises may be quite complex (see Case study 'Mapping blackberry in Nungatta Valley, NSW' p.32 for an example).



Stuart Roberton (DPI, Victoria)

Example of a blackberry management map made by using an aerial photograph.

Consider assessing blackberry infestations when blackberry is in flower to help identification.

Do you need to map blackberry or improve existing maps?

A Field Manual for Surveying and Mapping Nationally Significant Weeds was published by the Australian government (McNaught *et al.* 2006) to improve the consistency of data collected on a national scale. There are a minimum of 13 core attributes, including date, place, location and density.

The manual explains data collection in detail and guidelines have been prepared to assist communities and land holders to map weeds and develop local weed management plans. For a copy of the manual visit the Weeds Australia website: **www.weeds.org.au/mapping.htm** or phone 1800 020 157.

5. *Establish photo evidence of the infestation for future assessment.* Taking photos of the site is a good way to track changes over time. Take enough photos periodically (preferably at the same time each year) to ensure good site coverage. Mark photo points on the map to enable the accurate location of future images. Appendix 6 provides guidelines for establishing photo points at a site.

The following publications provide a framework for land managers to use in assessing a weed infestation:

- *A Field Manual for Surveying and Mapping Nationally Significant Weeds*, McNaught *et al.*, 2006 (available at: **www.weeds.org.au/mapping.htm**)
- *Introductory Weed Management Manual*, CRC for Australian Weed Management, 2003 (available at: **www.dpi.nsw.gov.au/weeds**).

Andy Wernert (DPI, Victoria)

Andy Wernert (DPI, Victoria)

Before and after control photos.

Case study

Mapping of blackberry in the Nungatta Valley, NSW

The Genoa River Interstate Liaison Committee (GRILCO)– a partnership between industry, the Victorian and NSW Governments, and private landholders– provides a good example of how mapping helps to ensure the efficient control of blackberry in the region.

GRILCO received Federal Government funding to use remote sensing (satellite images) to map the extent of blackberry infestations over 6414 hectares in the Nungatta Valley, located just north of the NSW-Victorian border in south-east Australia.

The principal objective was to determine the total area affected by blackberry and to use this data to plan control programs and monitor their effectiveness.

To map blackberry infestations, the NSW National Parks and Wildlife Service used a helicopter to fly predetermined transects of major blackberry infestations and record point locality data using a Global Positioning System (GPS). The point locality data were then used to start satellite imagery analysis.

Sample sites were also recorded from a four-wheel drive. Blackberry presence or absence at a site and the dominant canopy vegetation were recorded. Site position was recorded with a GPS.

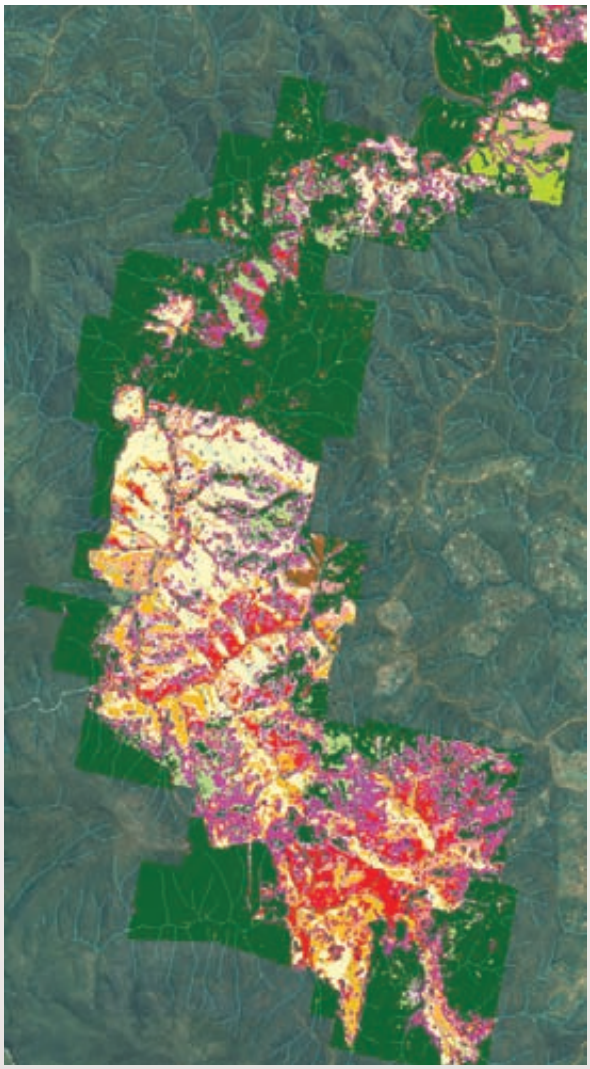
Summer and winter images were used to divide the study area into a manageable number of like vegetation classes. A 1:25,000 map was then generated to show the blackberry vegetation classes and the probability of blackberry occurring.

The two maps, when read in conjunction, showed that 26% of the Nungatta Valley was infested by blackberry. It also highlighted the fact that blackberry dominated most wetlands and was present in all gullies in the Nungatta Valley, and that 700 hectares of infestation could be managed only by using biological or pedestrian-based chemical controls.

Such information was critical for decision-making regarding the selection of appropriate control techniques and prioritisation of sites, and for assigning resources.

New satellite images will be used after three years to determine the success of the works across Nungatta Valley.

A list of selected references on blackberry mapping using remote sensing is available at **www.weeds.org.au/WoNS/blackberry**



NSW National Parks & Wildlife Service

Satellite maps produced for the Nungatta Valley in NSW.

As a general rule of thumb:

- first, protect blackberry-free areas at risk of becoming infested
- second, deal with areas where blackberry is present in a few well-defined populations
- finally, tackle large, well-defined areas of infestation, starting with the smaller outlying populations.

However, in some instances it is also important for a land manager to consider other strategies that may differ from the rule of thumb. An example of this is if a dense infestation is providing the seed source for new satellite infestations.

3.3 Prioritise the areas for management

To ensure best use of control techniques and resources, prioritise the areas to be managed:

1. *Identify the assets of a site.* Assets are the various ecological, economic or social features of the site to be protected by controlling blackberry (see Table 3.1). Assets will ultimately determine the priority of each site for treatment within the management plan, although other factors (identifying priority zone and vectors) will also influence priority-setting.
2. *Categorise the site by determining zoning.* Use Table 3.2 (p. 34) to identify priority zones for treatment. The Table is based on the principle that it is more effective to prevent blackberry establishment and to control small, isolated infestations to prevent re-infestation than it is to control dense, widely scattered infestations. However, this generalisation depends on the risk of reinfestation and the potential rate of spread.
3. *Consider invasion pathways.* Invasion pathways, or vectors (such as floods, animals or human activity–see Part 1, p. 16), can have a significant influence on the effectiveness of a control program. Management options that limit invasion pathways should be given a high priority in a blackberry management plan.

The final priority of sites for treatment will be a composite of the site zoning (see Table 3.2, p. 34) and the value of the assets at the site. Generally, sites with high-value assets are treated first and sites with fewer assets take a lower priority.

However, other issues may also be relevant, such as:

- the positive value of blackberry for fauna conservation (e.g. in degraded habitats removal of blackberry thickets can endanger native bird species that use these thickets for nesting or shelter)
- the increased threat of vermin in another area as a result of habitat loss (e.g. vermin deprived of the blackberry thicket for shelter may move to another area to find shelter)
- the stability of landforms or infrastructure, such as fences, that had been supported by blackberry bushes.

Table 3.1 Summary of ecological, economic and social assets.

ASSET TYPE	EXAMPLES	NOTES
Ecological	• Endangered or vulnerable vegetation communities • Sites of biological significance • Threatened plant or animal species	Expert knowledge may be required to identify individual species under threat and plant or animal communities of high conservation or habitat value. Consult with the local weed management authority or relevant State agency for advice on assessing these values before prioritising infestations.
Economic	• Areas with a high yield capacity or agricultural productivity	Valuing economic assets is site-specific and depends on the values of the assessor. For example, prime grazing land or irrigated land may be considered a high-value asset in a region where dairying or meat production is of economic importance.
Social	• Picnic or fishing areas • Camping sites • Sites with cultural or heritage value	The relative value of the asset depends on the values of the assessor and will vary from region to region.

Table 3.2 Summary of zones for prioritising blackberry management.

PRIORITY FOR TREATMENT, ZONE	SUMMARY OF ATTRIBUTES
1 **Exclusion zone**	Areas currently free of blackberry: prevention is the priority in such areas because it yields the greatest benefits compared with costs. **Priority actions required** • Assess the level of infestation in neighbouring areas. • Conduct ongoing surveillance. • Concentrate on assessing and monitoring invasion pathways. • Conduct a community awareness campaign. • Eradicate any plants found.
2 **Eradication zone, reduction zone***	Blackberry is present but only in a few well-defined populations (i.e. outlier populations). **Priority actions required** • Define the number and extent of eradication zones. • Eradicate all infestations by using appropriate techniques. • Monitor regularly after treatment for regrowth. • Conduct a community 'alert' program.
3 **Containment zone**	There are a few, large, well-defined areas of infestation with or without small outlier populations. **Priority actions required** • Define the number and extent of containment zones. • Begin management at sites where the spread is most rapid. • First, control to eliminate individual infestations on the boundary of the containment zone and work inwards towards the infestation to extend the potential dispersal distance. • Second, control within containment zones to reduce the impact on high-value assets, reduce infestation density, and prevent reproduction. • Monitor treated areas to eliminate outliers in surrounding areas and along pathways (e.g. streams, creeks, access paths, stock camps) for spread.
4 **Protection zone**	Primarily for sites that are threatened by existing infestations but where the climatic or habitat conditions are not suitable for blackberry establishment or where infestations are widespread and scattered. **Priority actions required** • Control to reduce impact at sites with significant ecological, economic or social assets. • Control to prevent spread from established infestations to sites with significant ecological, economic or social assets.

* Reduction zones are those where the cost of eradicating blackberry is greater than the benefits achieved. Actions required are consistent with those for eradication but over a longer period and including increased monitoring and evaluation.

Birgitte Verbeek (NSW DPI)

Vermin such as rabbits burrow in blackberry infestations.

Weather and seasonal events

Blackberry management plans need to be flexible. The spread of blackberry is often event- or season-driven, and the rate of spread can be reduced considerably if land managers react to these events with appropriate measures.

For example, events such as fire, floods, erosion or plant disease can cause an increase in the extent of bare areas that are vulnerable to invasion by blackberry (and many other weeds). Consequently, these areas, which may have been initially low-priority sites, may need to become a higher priority until the effects of the event have passed. If a fire has been through an area, control in the fire zone will be a priority in the following two or three seasons. Infestations within a few kilometres should also be treated to minimise seed sources.

The time following such an event is when maximum spread occurs, but it is also the easiest time to achieve control.

A decision support tool for prioritising blackberry at a regional level can be found at **www.weeds.org.au/WoNS/blackberry**

3.4 Set goals

Goals provide a focus for action in a management plan. They are statements of intent based on an estimate of realistic outcomes with clear timeframes that can be measured. Achieving realistic goals provides satisfaction with the progress of the plan, helping to avoid disillusion and fatigue, especially when the program is large and implemented over several years.

It is especially important to establish goals when the context for action can change. For example, the management plan may state that a particular infestation should be a priority. Then a flood occurs, with the consequence that the context of the infestation changes. The goal, however, remains the same and helps to determine whether or not another part of the infestation should logically be the target for action as a result of the flood.

Initially, it is information gathered from the site assessment and the prioritisation process that is used for setting goals for the priority areas. Use this information to set both long-term and short-term goals

For example, a short-term goal may be to control outlying infestations to protect a neighbouring site from invasion by blackberry. A medium-term goal may be to reduce the extent of blackberry to 50% of the original infestation within three years. A long-term goal may be to establish appropriate native vegetation at the site within five years.

Effective management and proper follow-up treatment in smaller areas is much better than large-scale one-off treatments that are difficult to follow up with further treatment.

3.5 The management plan

A management plan is the tool that documents how resources will be utilised over stated time frames to target particular problems. The management plan is the 'map' for achieving the set goal(s). Although the plan is an important document, it should not be seen as unchangeable. It should be regularly reviewed and revised to reflect variations in circumstances (whether those changed circumstances result from changes in available resources or natural events such as fire, flood or drought). The important point of reference in the management plan is the goal, and the important question is whether adjustments to the plan will better achieve the goal.

Part 5 (p. 71) contains an example of how a management plan was developed and implemented.

Developing your plan

Use the information gained when assessing the problem (see Part 3.2, p. 29), prioritising areas (see Part 3.3, p. 33) and setting goals (see Part 3.4, p. 35) to select appropriate management techniques (see Part 4, p. 39) and set time frames.

Lay out the plan clearly in a document. A well-prepared and documented plan helps to achieve goals and enables others–such as those who might be able to help with resources, including funding–to assess whether the program is worthwhile supporting.

Case study

Dispersal of blackberry seeds by emus and foxes

Research officers working in the Manjimup and Pemberton areas in Western Australia regularly saw emu families feeding on ripe and partially ripe blackberry fruit through January to April. They also noticed a large number of blackberry seedlings shooting within a confined area later in the year at sites where the emus had defecated after eating blackberry fruit.

Research conducted in Victoria measured the seasonal incidence and germination of blackberry seed in fox and emu faecal droppings. It was found that large quantities of blackberry seeds were present in the droppings of both foxes and emus. Emu droppings contained an average of 2460 blackberry seeds per dropping. Fox droppings contained a monthly maximum of 950 seeds per dropping. Many seeds were found to be viable.

The Victorian study concluded that foxes and emus are probably responsible for dispersing blackberry over large areas of Victoria.

Paul Yeoh (CSIRO)

Paul Yeoh (CSIRO)

Blackberry seeds found in emu faeces in Western Australia (above). Blackberry seedlings shooting in faeces in Western Australia (below).

The management plan should include at least the following five sections:

1. the goals
2. the control techniques selected
3. who is responsible for actions on the site
4. time frames
5. a financial plan that lists the resources needed to implement the control works, identifying those that are available and those that will need to be acquired.

3.6 Monitor and evaluate

An effective monitoring program helps to measure progress and gauge the success of a management and rehabilitation program. To be useful, results from monitoring activities should be recorded. The record can then provide a useful reference for evaluating past management activities and planning better future programs.

Detailed records of works and outcomes can also be useful for reporting on expenditure and publicity activities and in the event of legal action.

Use a book or diary to document the following monitoring activities:

- Note the apparent effectiveness–as well as cost-effectiveness–of management techniques.
- Record sightings of new seedling and re-growth. This will help determine follow-up treatment to prevent reinfestation.
- Use photos taken from original photo points (see Part 3.2, p. 29) to help with monitoring. Date, record image location and appropriately file the photos, either in the diary or specific file.

3.7 Follow up and rehabilitate

Ongoing follow up treatment is essential. Management plans must include allocation of time and resources for follow-up treatments.

Follow-up could include:

- Treatment of blackberry regrowth.
- Variation in the control techniques used. Part 4 (p. 39) gives details of the range of control techniques and how they can be integrated to choose the most appropriate method to manage blackberry at the site.
- Treatment of new weeds growing in cleared areas. If other weeds become established at the site following blackberry removal, it may be appropriate to contact the relevant State authority or local weed management advisor for advice on appropriate management options.

Case study

To retreat or not

A bushcare group in Bannister Creek, Western Australia, discovered the importance of monitoring and retreating sites where blackberry has been removed.

The group's goal was to clear a floodplain. Part of the work was to consistently retreat blackberry regrowth and remove other weeds that invaded the newly cleared areas. For five years the group achieved good results.

However, as a result of lack of funding, follow-up was suspended. Within 18 months, 15% of the floodplain had become reinfested with blackberry regrowth and new seedlings.

Luckily, monitoring of the site revealed the problem and blackberry control began again with new and improved treatments, restoring the site to being virtually blackberry free once again.

Follow-up should also include rehabilitation. This involves revegetation and maintenance of the treated area. Revegetation can be achieved by encouraging natural regeneration of vegetation (whether native or pasture) and/or by replanting with suitable replacement plants.

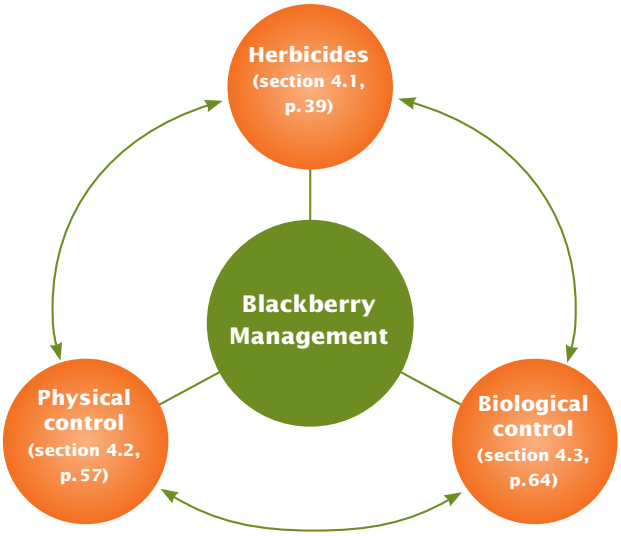
Part 4

Blackberry control practices

Summary

- The control of blackberry is a long-term process and cannot be achieved with one-off effort. This is particularly the case for larger infestations.
- There is a range of management options available for controlling blackberry, including physical methods, biological control and herbicides.
- Herbicides are highly effective tools for controlling blackberry, and their use is the most reliable method for achieving local eradication. Only herbicides registered for the control of blackberry or authorised under a permit should be used.
- The level of control with herbicides is variable and is influenced by a range of factors.
- The most appropriate technique for applying herbicides will vary among sites and depends on a range of factors. Techniques for application include foliar, cut stump, granules or gel, and aerial applications.
- Legislation in Australia generally requires a minimum level of accredited training for operators applying herbicides. The minimum industry standard level of training across Australia is Australian Qualification Framework (AQF) Level 3.
- Using physical control methods alone often leads to poor results. Combining a range of physical control methods with the strategic use of herbicides is a more reliable approach.
- There is currently only one biological control agent approved and released in Australia. The leaf rust fungus (*Phragmidium violaceum*) attacks only European blackberry. It is efficient at spreading by natural means where environmental conditions are suitable.
- There are also a number of natural enemies of blackberry in Australia, including the leaf-eating mite (*Acalitus essigi*), which attacks blackberry species, including those resistant to the rust fungus.
- Site rehabilitation is an important control tool. Revegetation with appropriate plants prevents or minimises reinvasion with blackberry and other weed species.
- Generally no single control option used in isolation will succeed. A control program should be well planned to consider all the management options available and to ensure they are appropriately integrated for maximum control. See Part 5 (p. 71) for an example of an integrated program.

Control of blackberry is a long-term process (Figure 4.1) and cannot be achieved by one-off strategies. This is particularly the case for larger infestations.



— Indicates integration between control options in a long-term management plan.

Figure 4.1 Overview of long-term management techniques for blackberry.

Integrated weed management (IWM) describes a combination of control methods used for the long-term control of a weed.

4.1 Control with herbicides

Herbicides are highly effective tools for controlling blackberry, and their use is the most reliable method for achieving local eradication. However, herbicides should be used as part of an integrated weed management program involving a range of control strategies. This section provides best practice management advice based on current knowledge and experience. It gives information additional to that provided on herbicide product labels.

Four factors should be considered when planning to use herbicides:

1. Most herbicides used in blackberry management are absorbed through the foliage or stems and leaves. However, some of the herbicides are also absorbed through the roots and can remain active in the soil (i.e. are residual) for some time (see 'Type and rate of herbicide used', p. 43).

The length of residual activity of a herbicide depends on the rate of application, the soil type, and the environmental conditions. Generally, herbicides break down faster when the soil is moist and warm.

2. A large proportion of a blackberry plant is underground in the crown and root system. Translocation of lethal quantities of herbicides into these parts of the plant is essential to kill the plant. Therefore, selection of the most appropriate herbicide and application technique is critical.
3. There are a number of techniques suitable for applying herbicides for blackberry management (see 'Herbicide application techniques', p. 50). The most appropriate technique to apply herbicides will vary between sites, depending on accessibility, associated vegetation, cost of application, the resources available and proximity to waterways.
4. The level of control with herbicides is often variable and can be attributed to one or more of the following:
   - variation in herbicide application
   - the timing of herbicide applications
   - the condition of the plants being sprayed
   - weather conditions at the time of spraying
   - the age of the plant
   - treatments before or following herbicide application
   - the plant species
   - the quality of the water used
   - the type and rate of herbicide used.

Monitoring the success of herbicide applications is very important to identify any areas that require follow-up treatment.

Case study

Consider the long-term effects when selecting herbicides

Rubus anglocandicans and *R. ulmifolius* occurred in continual thickets along the banks of the Warren River in Western Australia among mature native vegetation, including trees, and other shrubs, herbs, grasses and sedges.

A mixture of glyphosate, metsulfuron-methyl and Pulse® was used at recommended rates over several years to control the blackberry. This resulted in the total removal of all vegetation except the large trees. This in turn led to excessive erosion and riverbank collapses.

Had only metsulfuron-methyl been used in this situation, the sedges and grasses would have been retained, erosion may not have been a problem, and the intense level of revegetation now required to rectify the problem may not have been necessary.

When selecting herbicides, it is important to assess the situation and consider the long-term effects on non-target species.

Variation in herbicide application

Differences in the way herbicides are applied results in wide variation in the control achieved. Herbicide labels clearly describe herbicide dilution rates but less specifically indicate how wet the bushes should be after application (e.g. 'wet leaves and canes thoroughly' or 'use 3000–4000 L/ha of spray'). Although dilution of herbicide can be accurately controlled, the correct wetting of bushes is a greater challenge.

The most common error when spraying blackberry is to under-spray large bushes. Such bushes have an extensive surface area comprising the canopy, as well as leaves and canes at the centre of the plant. Spray operators may see that the outer foliage (canopy) appears wet and decide the plant is sufficiently sprayed. However, the inner parts of the bush may have received virtually no treatment. Experienced operators ensure that these larger plants get sufficient wetting of the inner leaves and canes.

Rule of thumb: Knowing the volume of spray to apply to each bush when spraying blackberry is critical to achieving a good result but very difficult to do in practice. As an example, a bush five metres in diameter and two metres high would require approximately 14.9 litres of spray (based on 3000–4000 L/ha). See 'Type and rate of herbicide used' (p. 43) for more details.

For spraying purposes, a blackberry plant should be viewed in three dimensions. The target plant is not a flat (two-dimensional) plane but a three dimensional object.

The most important factor is the amount of herbicide applied to the bush. Generally, lower volumes of water can be used if the concentration of herbicide is increased.

A study of 15 spray operators showed a 300% to 400% difference in volumes applied to treat the same bush. In this controlled study, all the applicators followed the same label directions and operated the same equipment. The large discrepancies in spray volumes were responsible for poor control due to under-spraying or increased costs from over-spraying.

One Weeds Officer's tip is: When spraying large infestations over a period of time, mark the areas already treated by tagging each bush with toilet paper. Toilet paper lasts longer than marker dye, is cost effective and eventually degrades without causing any environmental damage.

Timing of herbicide applications

The optimum time to spray blackberry is when it is actively growing from flowering through to fruiting–usually during December, January, February and March. However, this may vary between regions and species.

Blackberry can be sprayed before and after these months if conditions are suitable. Spraying summer active perennials like blackberry in autumn can increase the amount of herbicide translocated into the root system, because

translocation of starches and photosynthates to the root system is more pronounced when the season cools off. Plants do this to store increased energy reserves into survival tissues when the season starts to limit growth. Although autumn may result in better kill, it is essential to ensure plants are actively growing at the time of herbicide application.

Once plants lose their leaves from frost, cold conditions, insect or disease attack, spraying with foliar absorbed herbicides should be stopped.

Do not spray blackberry in spring unless there is enough top growth to absorb the herbicide and translocate it to the root system.

Rule of thumb: Have at least one metre of growth on canes before spraying to ensure there is adequate leaf surface area to intercept the herbicide. The canes must also be 'hardened off'. This means that the canes should be a little bit woody and not soft or succulent. Generally this occurs by January each year. Spraying of fresh growth should be delayed until hardening-off occurs.

Case study

The Western Australia experience

The regional variation in the optimum time to spray blackberry is evident from a Western Australia study. Research there showed that triclopyr + picloram mixes are best applied during November to April, when there is good leaf area and the plant is actively growing.

Metsulfuron-methyl is best applied from December to March, provided there is good leaf area and active growth.

Glyphosate tends to be more variable and provides good control only when there are good growing conditions.

Application of any herbicide should be avoided during the fruiting period in areas where the fruit is likely to be eaten.

Condition of the plants being sprayed

Control with herbicides is greatest when plants are actively growing and free of any stress (e.g. moisture stress). This is because plants are more able to absorb and translocate herbicides at this time. As a guide, look at the tips of the canes for new, soft leaves, as this indicates active growth and shows that the canes are mature enough for herbicide to be applied.

Extensive damage to blackberry leaves by insects or by diseases such as rust can affect the absorption of herbicide. Avoid spraying blackberry bushes if there is excessive leaf damage (see Part 4.3, p. 64 on biological control).

Weather conditions at the time of spraying

The weather at the time of spraying will also influence results with foliar-applied herbicides. Hot conditions during the day (i.e. over 30 ºC) can temporarily stress plants and limit the uptake or absorption of herbicides. Hot conditions coupled with low humidity will exacerbate this. During hot conditions, spray in the morning before 11.00 am daylight saving time (DST) or wait until weather conditions are milder.

A chemical advisor's tip is: If it is too hot for you to be out spraying and you feel uncomfortable or heat stressed, then it is too hot for the plant to absorb herbicide effectively.' If possible, try to spray early in the morning or late in the afternoon.

Age of plants

Blackberry seedlings or bushes in their first year of growth are easy to kill with herbicides, because there is a greater canopy to root crown ratio. In contrast, well-established blackberry thickets with large numbers of root crowns of varying ages are difficult to kill and may require follow-up treatment. Spraying small young plants will give high levels of control and will be less expensive.

Treatment before or after herbicide application

Pre-spraying treatments, including slashing and fire (which may have been used to gain access to the site, see Part 4.2 'Slashing', p. 57), previous herbicide application or physical removal can markedly affect the efficacy of follow-up herbicide applications:

- After slashing, burning or physical removal, ensure that sufficient top growth is present before herbicides are applied (see 'Timing of herbicide applications', p. 40).
- Previous herbicide applications may affect plant growth for up to two years. This in turn will influence the uptake and efficacy of future herbicide applications.

Rule of thumb: Slashing or burning should not occur after herbicide treatment until the canes are dead. Removing the dying canes too quickly can decrease the effectiveness of the herbicide treatment. Ultimately, the root system needs to be controlled and the canes need to circulate herbicides to the root system. Most labels state that an interval of **at least six months** after spraying is necessary before dead canes are removed. This varies with different herbicides.

Species differences

The success of herbicide treatment can vary among different species of blackberry because of differences in physical features. Some species produce fewer crowns per square metre than others, whereas some have larger leaves and canes, and others have hairier leaf surfaces. These characteristics affect the uptake and absorption of herbicide and the quantity of herbicide required to kill the plant.

Often there is more than one blackberry species growing within a large thicket. If herbicide is applied in this situation one of the species may be more tolerant to the herbicide applied. The more tolerant species will regenerate and spread, making the infestation more difficult to manage in the longer term. Both correct identification of the blackberry species to be treated (see Part 2, p. 20) and monitoring of the results of treatment over time are essential.

The growth form of blackberry species and the altitude can also influence the effectiveness of herbicide application. For example, *R. ulmifolius* and *R. leucostachys* have high crown and cane densities and can be harder to kill with herbicides than *R. anglocandicans*, which has a more open structure. In higher-altitude sites, sprawling, low-growing blackberry species are generally harder to control with herbicide than dome-shaped blackberry species.

Case study

Tumbarumba Shire Council

A noxious weeds inspector in the Tumbarumba Shire in southern NSW noticed that in particular areas and altitudes of approximately 1100 metres some blackberry bushes seemed more difficult to control than others. In these areas there were two growth forms of blackberry: a low-growing form with a sprawling habit (thought to be *R. leucostachys*) and a dome-shaped form with high-arching canes thought to be *R. anglocandicans*. Although herbicide application was consistent (Grazon® DS at 500 mL/100 L water), bushes growing side by side showed different levels of control, with the low-growing blackberry being more tolerant to the herbicide applied.

Although the variation in control was associated with altitude, species difference can also be a contributing factor.

Birgitte Verbeek (NSW DPI)

R. anglocandicans (pink oval) and *R. leucostachys* (orange oval) growing in close association near Kiandra in NSW.

Tip: A quick field test for water hardness is to try to lather soap: if it forms a lather then the water will not markedly affect the performance of herbicides, with the exception of glyphosate isopropyl amine.

The addition of two kilograms of crystalline ammonium sulfate per 100 litres of spray mix is recommended to reduce the possible effects of hard water on glyphosate. Aqueous solutions of ammonium sulfate such as Nufarm® Liase can also be used.

Water quality

Consider the quality of water used to apply herbicides. Use the best quality water available. Water suitable for human consumption is generally also suitable for mixing with herbicides.

- *pH*. The acidity or alkalinity (pH) of water in field situations rarely affects the performance of herbicides registered for blackberry control. However, high-pH (alkaline) water is often associated with high levels of calcium in the water, which may affect the efficacy of the isopropyl amine formulations of glyphosate such as Roundup®CT.
- *Water hardness*. This is a measure of the total soluble salts in the water. Standard hard water is defined as having more than 1000 parts per million (ppm) of calcium carbonate or lime:
  - Concentrations of more than 50 ppm of calcium can reduce the uptake of glyphosate isopropyl amine formulations in some plants.
  - High salt concentrations may also result in emulsifiable concentrates such as Garlon®600 not mixing well with water and separating.
  - Very high levels of calcium and magnesium ions (two minerals that make water 'hard') may bind with amine formulations, reducing the amount of active herbicide applied.
- *Dirty water* that contains suspended clay particles can reduce the effectiveness of glyphosate. Other blackberry herbicides will tolerate muddy water.

Type and rate of herbicide used

Herbicides registered for blackberry are marketed under a range of trade name formulations containing one or more active ingredients. Registrations may vary from State to State and year to year. Before starting a management program using herbicides, check what is registered or 'permitted' in the relevant State or Territory. For current information on registration details and current permits, visit the Australian Pesticides and Veterinary Medicines Authority (APVMA) website **www.apvma.gov.au**

The registered or permitted herbicide selected for any particular infestation will depend on a number of factors (see 'Herbicides at a glance', p. 44), including:

- management plan aims and goals
- current and future resources available (e.g. money and time)
- label specifications
- topography and climatic factors (e.g. wind and rainfall)
- surrounding vegetation
- proximity to waterways or wetlands
- whether it is associated with a legislative control area (e.g. chemical control area) or area sensitive to herbicides (e.g. horticultural or residential areas)
- the size of the infestation
- the method of application.

Active ingredients

Herbicides act by interfering with specific processes in plants. This is known as the herbicide mode of action (MOA). Different herbicides may have the same MOA. Table 4.1 (p. 45) lists the active ingredients registered for blackberry control.

There have been no recorded cases of blackberry developing resistance to herbicides and for most species it is highly unlikely because they are clones of the mother plant. However, one common species, *R. ulmifolius* is outcrossing and could develop herbicide resistance. Use of best practice such as rotating herbicides and using a range of control techniques will minimise any risk of developing herbicide resistance or of causing an increase of more herbicide tolerant forms.

See Appendix 8 for more information on herbicide resistance and MOA.

Herbicides at a glance

Five considerations when selecting a herbicide

- *Proximity* of the application site to *water*.
- *Selectivity of herbicide*. It is best practice in weed management to retain desirable species and maintain groundcover.
- *Cost of herbicide*. Low-cost active ingredients will not always give the best long-term control. Application costs for retreatment need to be factored into the decision.
- *Level of control*. Experience has shown that a mixture of triclopyr + picloram +/– aminopyralid will give the greatest long-term control.
- *Application costs*. For large infestations the cost of retreatment is often underestimated.

Situations for specific herbicides

Metsulfuron-methyl. Recommended for initial treatment of large, dense infestations.

Glyphosate. Recommended for small infestations that are easy to check and retreat and areas where other herbicides cannot be used, such as in or near watercourses and in urban and peri-urban areas.

Triclopyr. Recommended for initial treatment of large infestations.

Picloram. Recommended where the use of pellet formulations is considered the most appropriate application technique.

Picloram + triclopyr. Recommended for most infestations, both large and small, as it usually provides the highest levels of control.

Relative herbicide costs

Lowest cost to highest cost at the highest application rate– metsulfuron-methyl, triclopyr, picloram, glyphosate, triclopyr + picloram, triclopyr + picloram + aminopyralid.

Relative application costs

The cost for a contractor to apply herbicides can be up to $1000 per day and more if the site is difficult to access. One spray contractor said, *Most landholders focus on the cost of the herbicide without thinking through the application costs. Often it is far more economical to apply a higher cost herbicide which will give a better long-term result and minimise the time to come back with a follow-up treatment of a less expensive and less reliable herbicide.*

Mixtures of active ingredients

The most common mixtures of the active ingredients in Table 4.1 (p. 45) are:

- *Picloram plus triclopyr* (e.g. Grazon® DS, Conqueror®)
  This is the most reliable mixture of active ingredients for the control of blackberry and with correct application it will give the highest level of control. This formulated mix has recently come off patent and is now sold under a number of different trade names.
  Recently, aminopyralid has been added to the triclopyr + picloram mix and is marketed as Grazon® Extra. The manufacturer claims the inclusion of the aminopyralid to the mixture improves the efficacy on harder-to-control blackberry.

  Snapshot of picloram plus triclopyr mixtures:

  - Higher cost, but this mix will provide the highest level of control.
  - MOA Group I.
  - If herbicides other than Group I herbicides have been used previously, allow two seasons of regrowth before applying.
  - With aerial application, Eucalyptus species up to four metres tall can be killed; mature trees 15–20 metres tall may be party defoliated but are likely to recover.
  - Application to any native vegetation should be done in accordance with State and local regulations.
  - Crop plant-back periods apply.
  - Do not apply if rainfall is expected within one hour of application.
  - Expect reduced results if flooding occurs within nine months of application.
  - Grazon® Extra has a new label containing information about managing residues that may transfer from the pasture to the animal and then to manure in livestock slaughtered for export.

- *Metsulfuron-methyl plus glyphosate*
  (e.g. Cut-Out®, common tank mix)
  This is a common mixture of active ingredients used where companion weeds need to be controlled at the same time as the blackberry. However, there is no scientific evidence that the addition of glyphosate to metsulfuron-methyl improves the level of control for blackberry when compared with using metsulfuron-methyl on its own.

  Using metsulfuron-methyl alone will give some level of selectivity, such as the retention of grass species. Addition of glyphosate will greatly reduce the level of selectivity, but it may increase the number of other target species controlled.

  Snapshot of metsulfuron-methyl + glyphosate mixture:

  - B+M.
  - Apply between January and April when the bush is actively growing.
  - In Tasmania, apply after flower-petal-fall.
  - Do not apply to bushes with mature fruit if the fruit is likely to be eaten.
  - After application, symptoms take three to six weeks or more to develop, with full brown-out taking from three to six months.
  - Do not disturb the blackberry by cultivation, sowing or bulldozing for one month after application to ensure full absorption of the herbicide.

Adjuvants

An adjuvant is any substance added to a herbicide with the intention of improving the effectiveness of the herbicide. There are many products available, as well as a great deal of misinformation regarding the use of adjuvants. Always use the adjuvant recommended on the herbicide label. Alternatively, the adjuvant label specifies the herbicide product or active ingredient it can be used with.

Table 4.1 Summary of active ingredients registered for blackberry control

Metsulfuron-methyl
MOA Group B, e.g. Brush-Off®, Lynx®, Bushwacker®

How it works	Advantages	Disadvantages	Comments
A selective systemic herbicide that blocks a key enzyme system required for the production of proteins and used in cell multiplication and growth. Absorbed through the foliage and the root system.	• Low cost. • Low toxicity to mammals, fish and invertebrates. • Some selectivity, so grasses and other vegetation such as sedges can quickly provide ground cover and competition against reinvasion from blackberry seedlings or regrowth. • Little residual activity in acidic and neutral pH soils.	• Regrowth generally occurs and repeat applications are required. • Other trees and sensitive woody native species may be affected by high rates of metsulfuron-methyl. • Toxic to aquatic plants.	• Recommended for the initial treatment of large, dense infestations because of the low cost. • Active at very low concentrations (as little as 5 g/ha for some weeds). • Low cost, but follow-up treatment will be required. ** Generally applied between December and April.* ** Will cause a slow, steady death to both root and above-ground parts of the blackberry.* ** Do not contaminate streams, rivers or waterways with the chemical or used containers.* ** For control of bushes previously treated with other brush control herbicides or for bushes that have been burned or slashed ensure two years has elapsed before applying this herbicide.*

** denotes critical comment from the label*

Glyphosate

MOA Group M, e.g. Roundup®, Banish®360, Touchdown®

How it works	Advantages	Disadvantages	Comments
A non-selective systemic herbicide absorbed by the foliage. It translocates through the plants system, including the roots, and disrupts the production of essential amino acids that synthesise proteins and help in cell division.	• Becomes inactive on contact with the soil, so other species can be planted in treated areas following application. • Low toxicity to mammals and fish. • Some formulations are registered for use in, or close to, waterways or wetlands (e.g. Roundup® Biactive™) because they have lower toxicity to amphibians. Refer to the herbicide guidelines for use in and around water on the NSW DPI website (**www.dpi.nsw.gov.au/weeds**). • Suitable for use in sensitive areas such as urban areas, gardens or water catchment areas. • Relatively low cost.	• Level of control is often marginal and repeat applications may be required for several seasons. • Non-selective, so most other vegetation will be killed or severely affected. • Leaves bare ground under treated bushes; these bare areas may be invaded by other weeds.	• Recommended for small infestations that are easy to check and retreat, areas where other herbicide options cannot be used (e.g. in wetlands or along watercourses) and in urban and peri-urban areas. * *It is unlikely to give a complete kill of all underground parts, so repeated applications may be necessary, especially on large established bushes.* * *Apply from flowering to leaf fall.* * *The effects may not be apparent until the following season.*

Triclopyr

MOA Group I, e.g. Garlon®, Hurricane® 600, Invader® 600

A selective herbicide that has activity on a wide range of broadleaf weeds. It is a systemic, foliar-applied herbicide, absorbed mainly through the foliage, although it can also be absorbed through the roots. It does not have long residual activity in the soil. Once absorbed it is rapidly translocated through the plant. It has multiple sites of action within the plant, mimicking plant hormones and disrupting cell growth.	• Control of blackberries with no harm to grasses, ensuring competition against reinvasion. • Relatively inexpensive to apply. • Plants display herbicide symptoms within one week of application and complete brown-out in a month.	• Retreatment may be necessary. • Physical drift may affect trees and other native vegetation. • Cannot be used in certain areas (e.g. in chemical control areas of Victoria).	• In Victoria, an Agricultural Chemical User Permit (ACUP) is required to apply triclopyr. • Recommended for the initial treatment of large infestations • Moderately persistent in soil with a half-life of 46 days (range 30–90 days). * *Apply from late spring to early autumn when bushes are actively growing.* * *Any subsequent regrowth should not be sprayed until it has hardened off.* * *Do not burn, cut or clear treated blackberry for six months after spraying.* * *Where herbicides other than Group I herbicides have been used, allow two years of regrowth before spraying.* * *Do not allow physical spray drift onto waterways.* * *Do not contaminate waterways with chemical or used containers.*

** denotes critical comment from the label*

How it works	Advantages	Disadvantages	Comments
Picloram **MOA Group I, e.g. Tordon® granules, Vigilant® gel**			
Selective, systemic herbicide absorbed through the foliage or roots.	• Gives residual activity. • Formulated in pellets or gel; this may be desirable in some locations and can extend the time of application. • Will not kill grasses. • Low toxicity to mammals.	• Moderately toxic to fish. • Harmful to many desirable trees and shrubs where the roots from these plants extend into areas that are treated. • Mobile in the soil and may leach or move from the site of application.	• Recommended where pelleted formulation is considered the most appropriate application technique. • It is persistent in the soil giving an extended period of uptake by the blackberry. Half life of 90 days (range 20– 300 days).
Hexazinone **MOA Group C, e.g. Hexazinone 250 SL®, Velpar® L**			
Residual herbicide absorbed by the foliage and the roots.	• Low toxicity to mammals and fish.	• Mobile in the soil and may leach or move from the site of application. • Can cause severe damage or kill many desirable trees and vegetation. • Persistent in water (half life >56 days). • Slightly toxic to fish and aquatic organisms.	• Use only in pine plantations and around industrial buildings. ** Can be applied using foliar spray, spot application or stem injection.* ** For residual control from spot application sufficient rainfall is required after treatment to promote root absorption.* ** Do not apply on or near desirable trees or where there could be a surface flow of water.*
Amitrole + ammonium thiocyanate (This mixture is always sold as this drum mix.) **MOA Group Q, e.g. Amitrole T®, Weedeath® or Oxalis Sour Sob Killer®**			
Inhibits carotenoid biosynthesis.		• Some naturally occurring resistant weed biotypes exist. • Non-selective, so may damage crops, pastures and some ornamentals.	• Registered for use in and around non-crop areas, around buildings, commercial and industrial areas, gardens and public service areas and rights of way. ** Requires two applications during the one growing season, and follow-up treatment in the next growing season.* ** Apply in December/January and respray in autumn.* ** Limited use for control in many situations.* ** Do not apply to bushes with mature or developing fruit.*

** denotes critical comment from the label*

Case study

Examples of using herbicides to control blackberry

Choosing the right type of herbicide and the most appropriate way to apply it can be difficult. Land managers should consult their local chemical advisor for current advice before starting a herbicide control program, as the decision may be different depending on the site, the conditions, the equipment available and the funding available.

The following information gives examples of how the various registered herbicides in Table 4.1 (p.45) can be used. This should be used only as a guide to ask the chemical advisor the most relevant questions when developing a herbicide program.

Large, dense infestations (covering more than one hectare)

- If necessary for access, burn or slash canes in early winter to early spring.
- Apply metsulfuron-methyl (e.g. Brush-Off®) according to the label using a site-appropriate method when there is sufficient regrowth.
- Repeat the application of metsulfuron-methyl for one or two growing seasons after the initial application when regrowth is one or two metres long.
- Once the infestation is reduced to a small area, apply a picloram + triclopyr–based herbicide (e.g. Grazon® Extra) according to the label.
- Monitor the site for regrowth and retreat as necessary.

Small area or individual plants (covering less than one hectare)

- Apply a picloram + triclopyr based herbicide according to the label. Cover a two metre area around the bush to reduce suckering. Refer to the label for critical comments on withholding periods if livestock will have access to the site for grazing.
- Monitor the site and repeat annually until there is no regrowth occurring.

Natural bushland

- If required, burn or slash canes in late winter to early spring to gain access.
- Apply a picloram + triclopyr-based herbicide (e.g. Grazon® Extra) according to the label using a site-appropriate method.
- If regrowth occurs and trees show symptoms of being affected (e.g. leaf curl or leaf drop), treat with triclopyr (e.g. Garlon® 600), otherwise retreat with Grazon® Extra.
- Monitor the site and treat regrowth as necessary.

Sensitive areas

Apply a mixture of triclopyr + picloram with diesel (e.g. Access®) or gel (Vigilant®), using the cut and paint method. This may lead to suckering a metre or two from the treated crown; any suckering will require retreatment in the following season.

Urban areas

Use the recommended rate of glyphosate (e.g. Roundup®) to spray the foliage and canes while the blackberry is actively growing. Often there is very heavy fruit set and the new growth shows a characteristic 'witches broom' appearance. Control is marginal and will need to be repeated for several years. Grubbing may be required to achieve eradication.

Birgitte Verbeek (NSW DPI)

The 'witches broom' effect.

Safety concerns when using herbicides

Human consumption of blackberries

Blackberries are a popular berry fruit and many people pick blackberries from public areas. Therefore, it is important that in public areas signs be erected warning people that blackberries have been sprayed, particularly if spraying has occurred throughout the fruiting period.

In some States there are restrictions on applying herbicides to blackberries bearing fruit. Read the critical comments section on the herbicide label for more details.

Operator and environmental safety

Various legislation specific to each State governs the use of pesticides (including herbicides) across Australia. Legislation governs three main areas:

1. Environmental contamination
2. Human safety
3. Residue levels in agricultural produce.

The legislation also generally requires a minimum level of accredited training before a person is able to apply herbicides. The industry standard across Australia is to have a minimum level of training to Australian Qualification Framework (AQF) Level 3. This includes the competency units 'Prepare and apply chemicals' and 'Transport, handle and store chemicals'. In some States, such as Queensland and Western Australia, additional competencies are required for commercial operators. Accredited training courses are available through registered training organisations in each State.

Appendix 9 provides contact details for more information on legislation and training requirements in each State (training requirements differ from State to State, and legislation requiring training is regularly reviewed and revised).

Treating blackberry in watercourses and riparian zones

Blackberry often grows along watercourses and in wetland areas. Very few blackberry herbicides are specifically registered for use in or near waterways and wetlands. In addition, there may be State regulations imposed by environmental agencies and water authorities limiting which products are allowable in particular areas, especially if the catchment is a source of drinking water.

Roundup® Biactive™ (glyphosate) and other similar products are registered for use in aquatic areas and generally require many applications to achieve high levels of control. Such products damage a greater range of companion species than some other blackberry herbicides.

To use the more effective and selective blackberry herbicides, a minor use permit from the APVMA is required. Information on these permits, and application forms, are available on the APVMA website **www.apvma.gov.au**. To obtain a permit the applicant must be able to justify why the treatment is required near water, and the more information you can supply the better the chance of having it granted. Each permit is assessed on its merits.

The granting of permits for weed control near waterways is not guaranteed. It requires a detailed application that describes the proposed treatment technique and why it should be used, in terms of efficacy and controlling environmental impacts. If granted, it is likely that stringent controls will be enforced to ensure minimal off-target damage and non-pollution of water. Including a site assessment of the infestation (using a map and/or photographs) will increase the chances of the applicant successfully obtaining a permit. This information gives the assessor a better understanding of the proximity of the blackberry to the water, the size and type of the water body, and the extent of the blackberry infestation to be treated.

Avoidance of standard foliar applications could be a valid option, particularly if the infestation is rather small. In this case, permits may be granted for cut-stump applications of herbicide, where off-target risk is considerably lower. Describing proposed risk controls in the application will increase the likelihood of success. Recommended risk-control measures include reducing hand-gun spray pressure (minimising drift), directing the spray as much as possible away from water, and avoiding spraying at times when the risk of floods is high.

Ensure that an integrated approach to blackberry management is proposed. Non-chemical measures that suit this approach include grazing with goats, burning dead canes, grubbing out old crowns, introducing rust pathogens, providing a competitive pasture and removing obstacles such as logs that encourage the establishment of blackberries.

If the permit application is to succeed, a logical justification is required for an alternative herbicide. As glyphosate is the main herbicide registered for control in aquatic situations and it does not result in acceptable levels of control, it could be acceptable to use an alternative product on the grounds of efficacy. The preferred alternative herbicide to use near waterways is metsulfuron-methyl. It has high levels of efficacy whilst having relatively low aquatic toxicity compared with other alternatives.

Metsulfuron-methyl has little adverse effect on grasses, rushes and reeds but does kill ferns. Established trees usually tolerate this herbicide, provided that the foliage is not sprayed. Many broad-leaved species that are oversprayed will be damaged or killed. Aquatic species are rarely affected under normal field-spraying conditions at normal rates. Metsulfuron-methyl hydrolyses quickly in water. However, a condition of the permit may be monitoring of water quality to ensure that any residues are below a standard. The National Health and Medical Research Council (NHMRC) have guidelines for health or the Australian and New Zealand Environmental and Conservation Council (ANZECC) have guidelines for the environment.

Triclopyr is registered for blackberry control; it is more selective than metsulfuron-methyl and would be preferred in areas where ferns or other species that would be damaged are present. Its major drawback is that the registered formulation is toxic to fish and it is relatively persistent and mobile in soil.

A mixture of triclopyr + picloram + aminopyralid has usually provided the best control. The mixture rarely kills grasses (dependent on the actual application rate, see 'Type and rate of herbicide used', p. 43), although they may be burned off after application, and it doesn't affect rushes, reeds and ferns. Broad-leaved weeds and small trees that are oversprayed may be damaged or killed. Most established trees will not be affected, but some shallow-rooted species may be damaged by the picloram component, especially if their whole root zone is treated. Furthermore, picloram is slightly to moderately toxic to fish and other aquatic organisms. Due to the adverse characteristics of the mixture, a permit is more likely to be approved if limited quantities are being applied on small or isolated infestations or if the bulk of the infestation has been controlled by other methods.

Herbicide application techniques

Most herbicides registered for blackberry management are absorbed through the leaves and canes. A few are taken up through the roots. Following application directions as specified on the label will ensure optimum herbicide uptake.

To ensure high levels of control with herbicides:

- correctly calibrate and maintain spray equipment to ensure the herbicide is delivered to the plants at the right rate (see Appendix 10)
- read publications and attend training days on woody weed spraying and calibration
- read the label (particularly the critical comments on the label).

The following techniques are the most appropriate for applying herbicide to blackberry. The one chosen will depend on the site, equipment availability and infestation size.

Foliar spray application

Spray plants from all sides if possible, including daughter plants. For sprawling blackberry, ensure all runners are adequately covered with herbicide.

High-volume application

High-volume application with a hand gun is the most common method for spraying blackberry. Thorough coverage of all parts of the plant is essential. High-volume spray equipment can be mounted on various vehicles. There is a wide range of equipment available. Spraying blackberry requires hand guns capable of delivering high pressures. High pressures are necessary to penetrate dense foliage and cover tall bushes. Hand guns capable of 5–15 bar (500–1500 kPa) are used for this kind of high volume spraying.

Nathan Cutter (NSW DPI) and Silvan

Hand guns.

Nathan Cutter (NSW DPI) and Silvan

All terrain vehicle (ATV) spot sprayer.

Nathan Cutter (NSW DPI) and Silvan

Three-point-linkage spot sprayer.

Jane West (NSW DET Centre for Learning Innovation)

Spraying from a utility pack.

Nathan Cutter (NSW DPI) and Silvan

Spray packs with electric diaphragm pumps.

Tony Cook (NSW DPI)

Wide-cone spray.

Tony Cook (NSW DPI)

Straight stream spray (note that personal protective equipment is not being used because the operator is only spraying water as a demonstration).

The pumps for these sprayers may have their own electric or petrol motors, or they may be power-take-off (PTO) driven. The hand guns may be attachments to booms on tractor three-point-linkages or all-terrain-vehicles (ATVs), or they may be a dedicated unit on an ATV with its own small diaphragm pump used exclusively for spot spraying. They may also be a larger, tray-mounted utility model with a petrol motor.

All pumps should have pressure gauges and regulators to alter the pressure.

Selection of an appropriate nozzle is also important. Nozzles can either give a straight stream or a cone pattern and are also available in a range of sizes to deliver finer and coarser droplets. The choice of nozzle on the hand gun will be determined by the weeds being sprayed and the herbicide(s) being applied.

Adjusting the nozzle towards a straight stream gives good penetration to wet stems and canes. The nozzle can then be adjusted back toward the wide-cone pattern to wet the foliage.

Some hand guns come with a range of orifice discs. These are more versatile, as a change of orifice can deliver either a finer spray or a coarser spray, see Appendix 11 for information on orifice discs.

Herbicide labels will give a mixing rate (e.g. 500 mL/100 L water) but not always a spray or water rate. Even when a spray rate is given (e.g. 1500–4000 L/ha) the rate is not particularly helpful. The reason for this is that spray is not being applied to a flat surface. Blackberry leaves and canes need to be thoroughly wet with herbicide. Therefore, the volume needed to achieve good coverage will be about 50% more than if only the foliage had to be wet.

To achieve good coverage, and to make sense of a rate range in hectares, it is better to think of spraying the volume enclosed by the canopy rather than the area of the canopy. Table 4.2 can be used to estimate the required spray rate for a bush. For example, a bush five metres in diameter and two metres high would need 14.9 litres of spray.

When spraying sprawling blackberry bushes the outcome to be achieved is the same as for domed-shaped bushes: the leaves and canes should be thoroughly wet. The infestation should be treated in a systematic way to ensure that all of the bush, from the centre to the tips of each runner, is adequately wet with herbicide.

Table 4.2 Estimating the spray rate required for a domed blackberry bush.

VOLUME OF SPRAY PER BUSH IN LITRES, BASED ON 3000–4000 L/Ha			
Bush diameter (m)	**Bush height (m)**		
	1.5	**2**	**2.5**
4	7	10.5	15
4.5	8.6	13.6	17.6
5	10.4	14.9	20.6
5.5	12.3	17.6	23.8
6	14.4	20.4	27.3
6.5	16.8	23.5	31.1
7	19.3	26.8	35.3

Tony Cook (NSW DPI)

Dome-shaped blackberry.

Nathan Cutter (NSW DPI)

Example of a knapsack.

Low-volume application

Low-volume application may be required where water availability and access by vehicles and equipment is restricted. Several types of spray applicators can be used for low volume application, including:

- knapsack sprayers
- gas gun application
- control droplet applicators
- splatter gun.

With low-volume spraying the concentration of the active ingredients has to be increased to maintain efficacy. As with high-volume application, correct calibration of equipment is critical to ensure maximum herbicide efficacy.

Low-volume spraying is done mainly by using knapsacks that are pressurised manually. Some labels recommend the same settings as with hand guns. This is not realistic, as unpowered knapsacks are not capable of delivering either the same pressures or volumes as powered hand guns. Low-volume spraying is suited to smaller and less dense infestations of blackberry, because large bushes require good wetting of the inner canopy, a task that knapsack sprayers are not designed for.

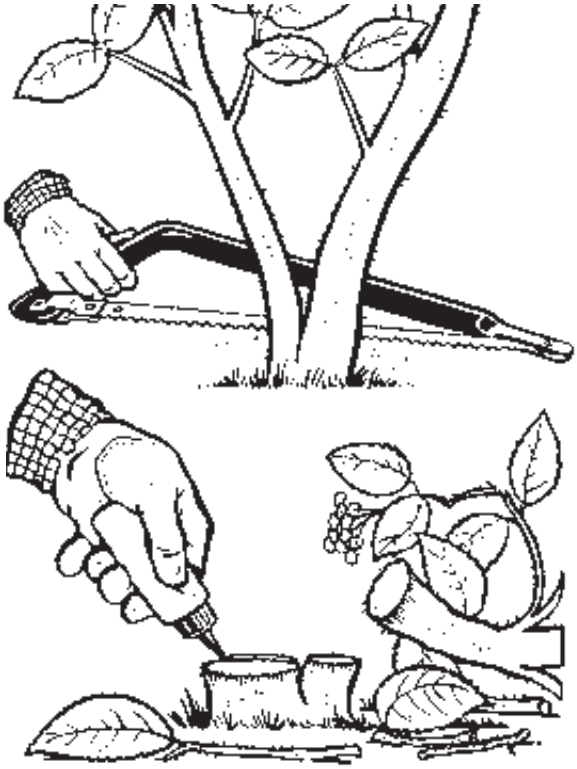
When spraying blackberry with a knapsack, ensure the plant is lightly and evenly sprayed so that foliage appears to have received a moderate misting. Wetting to the point of runoff when using a knapsack sprayer (low volume) is excessive and defeats the purpose of low volume spraying to use less water.

Tip: Low-volume spraying requires 10 times the concentration of product and uses ⅓–⅕ of the water rate than high-volume spraying. In other words, the concentration of active ingredient should be increased to compensate for the reduced wetting of the weeds. For example, if the high-volume rate for triclopyr is 16 mL/10 L (or 160 mL/100 L water), then the low-volume rate would be 160 mL/10 L (or 1600 mL/100 L).

Cut-stump application

This technique is labour intensive and consequently is used mainly on scattered plants in small areas or in areas of high conservation value to minimise the potential impact of the herbicide on non-target species. It can also be used as a follow-up treatment once larger infestations have been reduced.

Canes are cut off flat and straight close to ground level. The cut stems are coated with herbicide immediately after cutting. The herbicide must be applied immediately after the canes are cut, before the wound seals and sap flow to the crown stops. A delay of more than 10 seconds will give poor results. The herbicide can be applied as a gel (Vigilant®), with a paintbrush or pad, drench gun, knapsack or a hand spray bottle (used solely for that purpose and clearly marked).



Queensland Natural Resources and Mines

Cut-stump herbicide application.

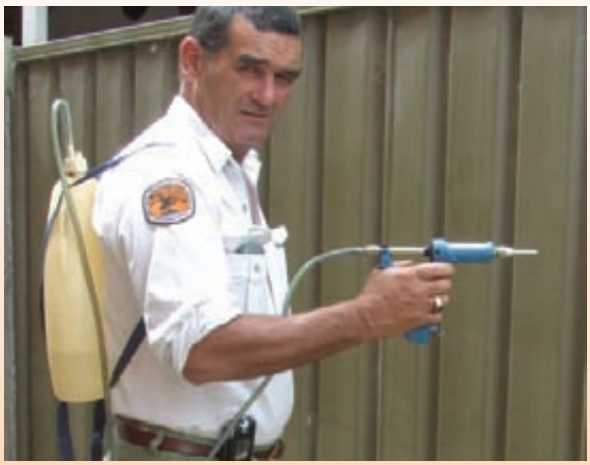
Case study

Use of the splatter gun

In the NSW Hunter Region, Ken England enthusiastically proclaims the benefits of using the splatter gun as a chemical applicator for controlling blackberries, among other weeds. He notes that he is often faced with a situation where the weed is in a relatively inaccessible area, such as the steep side of a hill; in an area where water needed for more conventional spray techniques is in short supply; or in a place, such as a watercourse, where it is particularly important to guard against overspray.

Ken notes, *for convenience, you can't beat the splatter gun. It is more economical than similar forms of equipment such as the gas gun or high volume spray applicators, and it can be carried in the vehicle ready for use at all times*. As it is not necessary to carry any extra weight (such as gas bottles for powering the equipment), the splatter gun is also convenient to carry when spraying needs to be done on foot or from the back of a horse.

For the control of blackberry, Ken has found that a concentrated mix of 335 millilitres of Grazon® DS to 10 litres of water–with a crop oil added at the recommended rate to aid penetration, improve rain fastness and to act as a marker is best. This mixture is 'striped' in measured amounts onto the weed at intervals. There is no danger of overspray. The crop oil serves to help the chemical adhere to the plant until it is absorbed. Also, as the oil leaves a shine, it helps identify where the application has been made. The best time for application is when the plants are fruiting (if they are not likely to be eaten by humans) and humidity is high (i.e. the stomata in the leaves are open and ready to absorb the chemical).



Ken England (NSW DECC)

Ken England from the NSW Department of Environment and Climate Change demonstrating the use of the splatter gun.

Granules or gels

Granulated herbicide formulations are applied to the soil surface, where they are moved into the soil by rain and taken up by the root system. The only chemical currently registered for this method of blackberry control is picloram (Tordon® granules).

The root area of the weed must be treated evenly. The pellets or granules must be spread to cover the ground under the plant and extend to 30 centimetres beyond the drip line created by the canes.

Granule applications are useful where spray applications are impractical or undesirable, for example in remote areas where water is not available or where plants are widely scattered. This type of application could also be undertaken in conditions that are not considered favourable for foliar applications. The herbicide becomes available to plants only after moderate rain, so the condition of the plant at the time of application is not so critical. For large bushes several annual applications are required, and it is rarely as effective as spraying.

Case study

The Spraying Mantis

The Spraying Mantis is essentially a long-reach, articulated arm with a spray head attached to the end of the arm.

Applying herbicide with the Spraying Mantis enables 5–10 times more area to be treated per day; moreover, the herbicide application is more thorough and even, giving a more consistent result.

The spray head is typically a medium- to high-volume hydraulic nozzle or a medium-volume mister. The spray head can be rotated on the end of the arm to allow the spray stream to be aimed in almost any direction. The whole unit is mounted on a four-wheel-drive or normal tractor to allow the navigation of rough terrain.

In Western Australia, the mister-style head is usually used for blackberry control because it enables deeper penetration of the spray into the bush. The ability to adjust the angle of the spray head allows better coverage of the foliage, and the air blast helps disturb the leaves to apply herbicide to both sides of the leaves. This increases the uptake and effectiveness of the herbicide by the plant.

More research is required to determine the best ways to use this technology However, field results have shown good levels of control with recommended rates of herbicides such as triclopyr, triclopyr + picloram and metsulfuron-methyl.

John Moore (Department of Agriculture & Food, WA)

Close-up of the Spraying Mantis.

John Moore (Department of Agriculture & Food, WA)

The Spraying Mantis mounted on a tractor.

Tip: Large and dense infestations often provide significant challenges for gaining access to undertake control actions. One land manager developed a unique approach of gaining access to a large infestation.

The process involved laying mesh over the blackberry, then driving a quad bike onto the mesh and spraying the blackberry on both sides. He then moved the mesh from behind the bike to the front and continued to move across the infestation in that way.

This broke up the dense infestation, allowing him to come back for follow-up treatment.

Care must be taken to avoid damage to non-target plants, particularly if the blackberries are growing under or near desirable species. Always read the label when using pellet herbicides.

Aerial application

Aerial application is commonly used to treat large areas quickly or to treat large areas that are inaccessible to other application methods. Aerial application is a specialised field and for this reason is not discussed in detail in this manual. If contracting an aerial operator to treat blackberry, make sure they are licensed under the appropriate National and State legislation.

Case study

The Maatsuyker Island experience

Maatsuyker Island is about 180 hectares in area and is located approximately 10 kilometres off the remote South West Coast of Tasmania. The island has significant heritage and natural values and is also a site of importance to the Tasmanian aboriginal community.

Blackberry (*R. fruticosus* agg.) is naturalised on the island, and initially different control approaches were applied depending on the size, density and location of the infestations. However, because of the sensitivity of the area, the majority of primary control has been by the 'cut and paint' method.

Initially, concentrated glyphosate with a pink dye marker was applied to cut canes with a shoe polish applicator. In subsequent years Garlon® was added to the glyphosate at a rate of 1.7 mL/L of concentrate, in accordance with a permit (PER 8949).

To increase the surface area to apply the herbicide, 10–30 centimetres of the base of each live cane was scraped over ¼ to ½ its diameter and the herbicide applied. The canes were then cut above the scrape on an angle (if possible) to increase the surface area and the herbicide mix applied.

This technique is labour intensive initially, but long-term it requires less follow-up treatment.

This method was found to be convenient on Maatsuyker Island because it minimises disturbance of native vegetation and wildlife, requires no specialist skills or training for volunteers, removes the need to carry large amounts of water, and is time effective because treated areas require little follow-up treatment.

The cut and paste method used on Maatsuyker Island.

Blackberry treated using the cut and paste method in the previous season.

Craig Saunders (Parks and Wildlife Service, Tasmania) *Craig Saunders (Parks and Wildlife Service, Tasmania)*

4.2 Physical control methods

The use of physical control methods alone often gives poor results. Physical removal of blackberry top growth will result in the death of only the crown, even when the regrowth is repeatedly removed for three to five years.

Combining a range of physical control methods with the strategic use of herbicides is a more reliable approach.

Hand and mechanical removal

Manual removal is generally not suitable in most infestations. Seedlings and small plants are difficult to pull out without breaking the roots.

Follow-up control and site rehabilitation are essential if hand or mechanical weeding is used, as regrowth from crowns, root fragments and seed is inevitable.

Hand removal

Hand removal (removing the top growth of the blackberry and digging up the roots) is most suitable for small and isolated infestations.

Blackberry can produce root suckers from a depth of at least 45 centimetres, so it is essential to remove as much of the root system as possible. The process is time consuming and difficult but can be successful.

Grubbing

Mechanical grubbing is a good compromise that is suitable for scattered infestations of mature plants. With this method, whole blackberry plants are removed by an implement attached to a tractor, backhoe or excavator.

This technique completely removes the infestation with relatively low site disturbance, allowing immediate regeneration of the area.

Scalping

Scalping to a depth of 20–30 centimetres with a root rake or similar equipment can be very successful on accessible infestations. Care must be taken to remove sufficient material to ensure that the crowns and the majority of the roots are removed.

Cultivation

Cultivation is the process of digging up or cutting the soil to prepare a seed bed, control weeds, aerate the soil, or work organic matter, crop residues, or fertilisers into the soil. A single cultivation can spread blackberry rather than help control it, because root fragments are distributed over the cultivated area. This is usually the case if the cultivation is done in winter.

Cultivation needs to be frequent and undertaken at the appropriate time of the year (usually summer) to achieve good control.

Consult your local weed management agency or agronomic advisor before you cultivate. Consider integrating cultivation options with other blackberry management options.

Large earthmoving equipment

Using large earthmoving equipment may be an option in specific situations. However, it is unlikely that all root material will be removed, and follow-up treatment with herbicides will be required to achieve control.

Large earthmoving equipment can be used to cut access tracks into large, dense infestations. Other management options such as the use of herbicides or grazing by goats can then be used successfully.

Slashing

Slashing should be considered only as a short-term control method. It may be useful in accessible areas to reduce plants to a more manageable size or to open up dense infestations for follow-up treatment using other techniques.

Regular slashing on a fortnightly or monthly basis encourages the blackberry to regrow and use energy reserves stored in the root system. This in turn may reduce the size and vigour of the infestation. However, it is very expensive and not very effective.

Irregular slashing can leave the plant with a stronger root system and little top growth, reducing the effectiveness of any follow-up herbicide application. It may also stimulate suckering, which increases the density of the blackberry plants.

Before implementing a slashing operation, consider the cost of labour and machinery and the ongoing financial and time commitments necessary.

Case study

Improving access for controlling blackberry

Gaining access to the large blackberry thickets around Mountain Creek near Holbrook in NSW seemed the best option to begin the process of controlling the infestation. The thickets were too large to spray by hand and too close to tracts of native vegetation and pine plantations for aerial spraying.

The area was steep and initially heavily timbered before it was cleared for development in the 1980s. It had become increasingly choked with blackberries over the past two decades. In 2004 landholders in the area, the Murray Catchment Management Authority (CMA) and the Greater Hume Shire Council formed a cooperative. The cooperative's plan was for operational staff from the Shire to initially clear the blackberry from the creek; landholders would then be responsible for maintaining the cleared area. The Murray CMA provided funding and helped with the revegetation.

In early January operational staff used a large front-end loader to push tracks into and through the blackberries. The tracks made through the blackberry were then used as access for spray vehicles to apply herbicide.

According to Tom White from the Greater Hume Shire Council, *we now push tracks into all large infestations of blackberry if possible. Access to large infestations of blackberry is essential if chemical control options are to be used. Access reduces the likelihood of the insufficient application of chemical to areas that you cannot see and reach. It reduces the spray pressure needed to do the job, which reduces possible drift and improves occupational health and safety issues.*

Tom White (Greater Hume Shire Council)

Tracks cut into the blackberry infestation to allow access of spray vehicles.

Case study

Huonville Landcare Group

In Tasmania, the Huonville Landcare Group Inc., in consultation with Huon Valley Council, is managing blackberry at a local site in a slightly unconventional way. They have first reduced all the bushes to ground level by brush-cutting before spraying the regrowth with a triclopyr-based herbicide at the recommended rate.

The five hectare site had a broad thicket of mature blackberries approximately 30 metres deep around the eastern, southern and western edges, and over two metres high in some places. The two species of blackberry present grow predominantly on the drier, disturbed soils on the site and not on the waterlogged soils. The whole site is covered in black gum (*Eucalyptus ovata*) forest, which is a threatened vegetation community in Tasmania, and therefore requires extra care to limit the impacts of control.

The decision to reduce the size of all the plants with brush-cutting rather than just gaining access into the infestation was made for several reasons:

- to reduce the difficulty for contractors to safely and effectively foliar spray the entire infestation
- to reduce the potential negative public response to a large area of dead blackberry in the reserve, which is adjacent to a public road
- to minimise the amount of herbicide used in the reserve
- to reduce any potential off-target damage to the surrounding vegetation.

After the size of the thicket had been reduced by brush-cutting–a process that took almost two years–the regrowth was sprayed once the canes had regrown to approximately 50 centimetres. Any isolated blackberry bushes in the wet areas of the site were grubbed out or cut and painted with Roundup® Biactive™ at the recommended rate; this herbicide is registered for use in or near waterways.

The group has approached the neighbouring landowners and encouraged them to control their blackberry as well.

Richard Greenhill (Huonville Landcare Group Inc.)

Richard Greenhill (Huonville Landcare Group Inc.)

The Huonville black gum forest before (top) and after (above) brush-cutting of the infestation.

Richard Greenhill (Huonville Landcare Group Inc.)

After control of the blackberry the Huonville Landcare Group Inc. will rehabilitate the site.

Case study

Manual removal of blackberry on a Melaleuca floodplain

The problem

Blackberry thickets (*R. laudatus*) covering 20,000 m^2 and reaching up to five metres into the tree canopy confronted the Bannister Creek Catchment Group (BCCG), City of Canning volunteers and contractors in 1997. The infestation dominated the understorey of the *Melaleuca rhaphiophylla* and *Eucalyptus rudis* floodplain of Bannister Creek, which runs through the southern Perth suburbs of Lynwood and Ferndale in Western Australia.

Julie Robert (Bannister Creek Catchment Group)

Manual removal of blackberry was chosen at Site A because the site was close to water. Thick blackberry grew to the edge of the watercourse.

Julie Robert (Bannister Creek Catchment Group)

Site A after the blackberry had been removed.

The team of three volunteers and two paid workers were reluctant to use broad-scale herbicide spraying, because:

- the poisoned plants would leave large areas of flammable dry material in an area that could legally be burnt
- it was likely that remaining understorey species would also be killed by the herbicide
- high-level herbicide use is not acceptable practice on floodplains.

Method developed

The group developed a technique for the manual removal of blackberries:

- *Use of protective clothing*. It was important for workers to adequately protect themselves. This included gloves with double leather-stitched palms (commercial fencing quality), long-sleeved shirts, long trousers of good quality fabric, and hat and safety glasses.
- *Sensible pacing*. The work was physically quite strenuous. The team found that a six hour working session was a good rate. In this time, they could clear blackberry canes from about 20–30 m^2.
- *Break and pull*. Work sessions started by breaking canes with metal rakes to open a hole in the thicket. This allowed a visual field into the undergrowth. Team members then pulled free one cane at a time, breaking or cutting the cane from the main root base and freeing it from the entangled mass. The person pulling the cane stepped backwards, using their body weight to pull the cane free while folding and winding it. This technique minimised the danger of the cane scratching the handler and made it easier to dispose of the long stem when it was free.
- *Removal of root base*. After pulling or cutting all canes from the main root, team members dug up the root if possible. Roots that could not be removed, such as those wedged under tree roots and logs, were tagged with coloured tape for later monitoring and treatment with herbicide when sufficient regrowth enabled good herbicide uptake. Sometimes it took several herbicide applications to kill the root. Initially the team also tried to pull out ground roots and runners, but they found this difficult to do and not very fruitful, as any root segment left in the ground sprouted a new plant.

Case study (continued)

Manual removal of blackberry on a Melaleuca floodplain

- *Waste removal*. Team members either stuffed folded canes into weed bags or placed them onto weed mats. At the end of each work session, they carried these bags or mats to a nearby firebreak or path for removal by the land manager. After an area had been cleared, workers raked the site and removed any dead canes (dead canes did not break down easily in the shaded and damp conditions and could be a hazard underfoot).

Julie Robert (Bannister Creek Catchment Group)

The folded blackberry canes were placed on weed mats and dragged out of the site for disposal.

- *Follow-up*. The team followed up meticulously for five years, wiping or spraying blackberry regrowth with undiluted glyphosate as well as removing other weeds that invaded newly cleared areas.
- *Natural regeneration*. The team undertook no plantings for three years. Instead, they actively controlled weeds to encourage natural regeneration.

The bushcare team found that regrowth after the initial treatment did not have large root bases. The majority of regrowth was from horizontal ground runners that grew multiple upright stems, making it possible to see them among weed growth and identify where treated plants had been. To treat the regrowth the team cut the stems 500 millimetres from the ground and then treated the cut with a mixture of glyphosate and metsulfuron-methyl at the recommended rate. The group used this herbicide technique only during dry conditions, and only a few treated plants required a second herbicide application.

Julie Robert (Bannister Creek Catchment Group)

The blackberry infestation at Site B before work began.

Julie Robert (Bannister Creek Catchment Group)

Site B after a substantial amount of the blackberry had been removed.

Grazing by goats and other livestock

The use of goats is a proven method of managing blackberry infestations, because they preferentially graze blackberry over improved pasture species. Follow-up monitoring and treatment once the goats are removed is necessary, and there is also the potential to spread the blackberry if the goats are moved to an uninfested area.

The following factors need to be considered when using goats to manage blackberry:

- Appropriate fencing to contain the goats. It should be clear of stumps, fence supports and banks that allow goats to escape.
- Consumption of non-target plants. Goats eat a range of other plants and may destroy native and other desirable vegetation as well as the blackberry if they are confined in an area for too long.
- Threat of predation by wild dogs.

Details of a typical program that uses goats to manage blackberry in grazing land are given in *Weed control using goats: A guide to using goats for weed control in pastures* (MLA, 2007). This publication can be downloaded at **www.mla.com.au/default.htm** or ordered from Meat and Livestock Australia by contacting 1800 023 100 or **info@mla.com.au**

Case study

Using goats for blackberry control

Orange City Council in NSW used goats as a blackberry control option on a 12 hectare council reserve that had previously been a deer park. Council staff estimated that the cost of using chemical control in the particularly heavily infested reserve would be $5000 initially, plus follow-up costs. The cost of 30 boer goats delivered on site was $1200. After consultation with the NSW Department of Primary Industries and research on various Internet sites, boer goats were chosen because of their minimal maintenance requirements.

Fortunately, there was fresh water in the reserve and a 1.8 metre fence to contain the goats.

The goats were drenched before delivery and every 18 months after that. The male goats were castrated to enable Council to use female and male goats separately and together. Apart from this basic care, the goats needed no further maintenance. It was, however, important to ensure that the fencing remained in good order.

The goats appeared to do minimal damage to desirable species still left in the reserve; stock levels were monitored and reduced as the weed burden was reduced. Saplings that seemed in danger of being damaged were protected with plastic mesh guards to a height of two metres.

According to Council staff, *the success of the goats was outstanding!* The goats reduced bushes with a spread and height of more than 3 × 3 metres to almost nothing. If left to graze in the reserve, the goats would probably have continually controlled the blackberries. However, the goats were removed after five years and relocated to another area. Weed control is maintained by spot spraying with Grazon® DS at a rate of 5 mL/L of water, applied with a high-volume hand gun, or by cutting and painting with full-strength glyphosate.

Roger Smith (Orange City Council)

Goats controlling the blackberry infestation.

Cattle will not control blackberry infestations. However, they will reduce tip rooting and the establishment of daughter plants. Sheep may graze blackberry seedlings; their ability to prevent establishment depends on the availability of other feed and on the stock density.

Pasture management

In agricultural areas existing pasture management or re-establishment is an important component of a blackberry management program. Generally, the presence of weeds, including blackberry, is a symptom of pasture decline. Strong, actively growing pasture will help to prevent invasion from weeds.

There are many components to effective pasture establishment and management; these components vary from region to region and include:

- management plan aims and goals
- soil fertility and pH
- pasture establishment techniques
- pasture species composition
- fertiliser requirements
- ongoing grazing management.

Consult local livestock or agronomic advisers when planning a pasture improvement program.

In some States, legislation covering the conservation of native vegetation may regulate some pasture improvement practices where existing pasture contains native species. Contact your local environmental agency for further information before undertaking pasture improvement practices.

Burning

Burning will not kill blackberry. Anecdotal evidence suggests that burning can increase the size of the infestation because of increased tip rooting, increased seedling recruitment and increased growth owing to reduced competition. Nevertheless, burning can be used as a tool for managing blackberry. Two scenarios should be considered: burning before herbicide application and burning after herbicide application.

Burning before herbicide application

Burning may be useful in certain situations to reduce plants to a more manageable size and to open up dense infestations for follow-up treatment.

Bushfires are a normal occurrence in many natural ecosystems in Australia where blackberry has invaded. These bushfires open up areas, enabling access to large, dense infestations.

In these situations, **allow at least one metre of cane growth before using foliar applied herbicides** (see 'Timing of herbicide applications' in Part 4.1, p.40).

Burning after herbicide application

Burning after herbicide application can be used to clear away dead canes. However, **treated infestations should not be burnt until all the canes are dead to allow sufficient time for the herbicide to take full effect**.

If blackberry regrowth occurs after an initial herbicide application and subsequent burn, follow up with a herbicide containing picloram.

Tom White (Greater Hume Shire Council)

Burning blackberry after treatment with herbicide, Tumut Shire.

Case study

Burning blackberry

The use of fire to control blackberry is generally ineffective: even though stems are destroyed, the woody crown and root system are only slightly affected. Even after the intense wildfires in the ACT in 2003, officers from Parks, Conservation and Lands (PCL) found that regrowth occurred from root systems in the next year.

Researchers investigated whether the crown and root system were affected by the intensity of the fire. They chose a number of plots after the intense fires in Victoria in 2003. They found that all the blackberry plants survived the fire, but there was no simple relationship between blackberry recovery and pre-fire blackberry abundance.

In one plot there was a large number of crowns pre-fire but a low blackberry density two years later. One possible explanation for this is a combination of a hot fire and shallow stony soil; this would have reduced the blackberry roots to a few fragments and led to regrowth that was unable to compete successfully with native shrubs and trees establishing from seed.

In other plots, dense blackberry stands became established with little competition from natives. These plots had been farmland or had only a sparse native vegetation cover where the native vegetation seed bank had been depleted before the fire.

The researchers suggested that an effective post-fire intervention may be to perform heavy seeding with local native shrubs. This observation was echoed by PCL staff:

What we ideally need to be able to do is burn dead canes after we have sprayed them so we can plant or seed native plants. Otherwise we end up with weeds or eventually new blackberries growing among the protection of old dead canes.

PCL staff also noted that it was important to allow enough blackberry biomass to regenerate after a fire before the plants were treated with herbicides; otherwise the growing canes would not convey sufficient chemical to the crown and root system to kill them.

4.3 Biological control

Biological control is the use of natural enemies such as diseases, mites and insects to suppress and weaken the target weed.

Biological control programs assess the pests and diseases found on overseas populations of the weed. After rigorous testing, these agents are released, mass-reared, and distributed into weed populations across Australia. However, not all agents become established effectively or have an impact on the weed. The diverse nature of the Australian environment often results in some agents doing well in some localities and not others.

Currently the only biological control agent tested and released into Australia is the leaf rust fungus (*Phragmidium violaceum*), which attacks only European blackberry. The rust is highly efficient at spreading by natural means and will colonise blackberry when environmental conditions are suitable. Therefore, land managers do not need to redistribute the rust.

There are also other diseases and pests of blackberry present in Australia. They are less useful as tools for controlling blackberry because they can potentially also attack native blackberry species or commercial species. They include the leaf eating mite (*Acalitus essigi*), blackberry orange rust (*Kuehneola uredinis*), *Septoria* leaf spot (*Septoria rubi*) and *Cercospora* leaf spot (*Cercospora rubi*).

The blackberry leaf rust fungus

The blackberry leaf rust fungus (*Phragmidium violaceum*) is effective only on European blackberry species. It does not infect American or Asian species, species native to Australia, or commercially grown species like raspberry, loganberry, boysenberry and youngberry.

Blackberry leaf rust fungus primarily attacks the leaves of blackberry and causes defoliation. It can also be found on flower buds and unripe fruit. The tips of the heavily attacked stems die back, preventing the production of daughter plants at the end of the stems. The rust also obtains nutrients and water from the blackberry plant cells, reducing the plant's overall ability to grow and reproduce.

The rust usually appears as characteristic purple-brown blotches, 2–3 millimetres in diameter, on the upper surface of the leaf. Corresponding golden or black pustules, or small blisters from which the spores emerge, appear on the lower surface of the leaf. Heavily infected leaves turn brown, shrivel and fall from the canes.

Rust spores require dew, rain or high humidity to germinate. Infection levels are greatest when blackberry is actively growing and a large proportion of the plant canopy is young leaves.

Localities where the annual rainfall is greater than 750 millimetres and evenly spread over the full year, and the average daily temperature for January is about 20ºC, have been found to be optimal for this rust species. Therefore, blackberry rust is more effective in the higher rainfall areas south of the Dividing Range in south-east Australia. The impact of the rust in drier areas appears to have been mostly minor and patchy. The rust may perform well in lower rainfall areas if humidity is higher, such as near irrigation channels or in riparian zones.

The strategy being implemented to facilitate the spread of the new strains of the fungus recently introduced to Australia is to release them at a range of sites across Australia to help the natural spread of the agent. It is well documented that the rust can spread over long distances. The new strains may become established, build up and hybridise with the existing rust populations, and better rust genotypes could emerge. The better genotypes that emerge will enhance the biological control of blackberry at some sites and eventually will spread to other infestations.

Life cycle of the blackberry leaf rust fungus

There are five separate spore stages in the life cycle of the rust.

The two commonly seen stages are the golden powdery summer spores (urediniospores) and the sticky, black, mostly winter spores (teliospores).

The golden summer spores first appear in late spring following the emergence of new primocanes and have several generations on young leaves. Summer spores germinate in the presence of moisture. They infect the blackberry when the germ tube enters the leaf through the stomata (breathing pores), found only on the lower surface of the blackberry leaf. Summer spores are microscopic and are carried by air currents, spreading the infection to other leaves, canes and plants. They have a generation time of 8–10 days under optimal conditions.

In late summer and throughout autumn, the pustules produce black, sticky, over-wintering spores. These remain attached to leaves that fall off or remain on the blackberry during the winter and are dormant until the next growing season. They are responsible for starting the next cycle of rusting infection on new spring leaves.

Leaf age affects the level of infection; the most susceptible leaves are the young, fully opened leaves at the cane tips.

CSIRO Entomology

The blackberry leaf rust fungus (*Phragmidium violaceum*).

CSIRO Entomology

Blackberry leaf rust fungus. Heavily infected leaves turn brown, shrivel and fall from the canes.

CSIRO Entomology

Blackberry leaf rust fungus: powdery summer spores (urediniospores).

CSIRO Entomology

Blackberry leaf rust fungus: sticky, black winter spores (teliospores).

Case study

Outcomes of biological control in Victorian studies

Biological control agents are unsuitable where immediate control is needed and the agents will not completely control blackberry.

These agents are living organisms. To build up their densities to damaging levels they need suitable climatic conditions. For the same reason, the results of biological control can vary from region to region and from season to season.

The advantage of biological control agents is that they are self-perpetuating and can generally spread without help. Therefore, they can play an important role in the integrated control of blackberry by suppressing the growth and vigour of an infestation.

Victorian studies over a 10 year period found that in sites where the blackberry leaf rust (*P. violaceum*) was established, the above-ground biomass was reduced by 38% – 56% and the number of daughter plants produced was reduced by up to 96%.

Impact of blackberry leaf rust

The rust cannot eradicate blackberry. Its main application and usefulness are in areas with large infestations where accessibility is limited. Use of the rust must be integrated with other management techniques to achieve good weed management outcomes.

Rust epidemics result in shorter canes and less fruit and seed, together with the production of fewer daughter plants at the cane tips. Continuous defoliation weakens the blackberry, forcing it to use the energy reserves stored in its root system and allowing light to penetrate the infestation. This helps to establish other vegetation.

Rust epidemics can look spectacular, but it takes persistent attacks over at least 10 years before significant reductions in crown size, cane length and leaf cover occur.

Situations in which the rust is unsuitable for control

There are some situations in which biological control is not a suitable method:

- *Small infestations of blackberry*. The leaf rust fungus is not an appropriate control method if the infestation is small, with only scattered and isolated plants. In this case other management options should be used, such as herbicide application or mechanical methods with the goal of local eradication.
- *Infestations where a herbicide control program is under way or is planned*. The effectiveness of foliar herbicides can be drastically reduced when they are applied to severely diseased plants.

Situations in which the rust is suitable for control

Biological control is a suitable management technique in the following situations:

- *Large widespread infestations*. Large infestations provide a substantial supply of blackberry for the leaf rust fungus to develop. Climatic conditions must also be suitable.

- *Infestations where other management options are not suitable*. Use of the leaf rust fungus is most appropriate where it is not economic or feasible to use other methods of control such as herbicides or mechanical removal. Infestations that are difficult to access or where sensitive native species are present are examples of where biological control may be a good option.

Other natural enemies of blackberry

There are several known natural enemies of blackberry present in Australia that have not been deliberately released as biological control agents but can add additional stress to blackberry plants.

Red berry disease mite (Acalitus essigi)

This mite causes 'red berry disease' in cultivated and weedy blackberry species in Australia and other parts of the world, including Europe, North America, Chile and New Zealand. Fruits infested by the mites do not ripen; that is, they remain red instead of maturing and turning black.

The mite has potential value as a biological control agent because it attacks a wide range of blackberry species, including species that are resistant to the European blackberry leaf rust fungus. However, it does not damage the rest of the plant, so it can be considered as an option only for preventing the spread of the weed.

It may also be useful in the management of commercial varieties of raspberry or blackberry that are escaping from orchards and becoming naturalised.

Paul Yeoh (CSIRO Entomology)

Red berry disease on *R. laudatus*.

Although the mite can affect commercial blackberry operations, it appears to have limited dispersal once established, and routine chemical treatments appear to be effective in its control. Continued research on the potential of the mite as a biological control agent is needed before active distribution can be contemplated.

Kuehneola uredinis

Kuehneola uredinis is another rust that can produce small powdery pustules on the lower surface of leaves. It differs from *P. violaceum* in that the pustules on the leaves are only pinpoint sized, are more orange, and do not produce the corresponding purple blotch on the upper leaf surface. This rust tends to attack the older leaves of blackberry in late summer and autumn but can also cause large, powdery, orange pustules up to one centimetre long that break through the bark of the second-year canes.

Paul Yeoh (CSIRO Entomology)

K. uredinis on the top side of a leaf.

CSIRO Entomology

Blackberry leaf rust fungus (*P. violaceum*) on leaves and the floricane.

Septoria leaf spot (Septoria rubi)

This leaf spot is very rare and is identified by purple-brown blotches 1–2 millimetres in diameter on the upper surface of the leaf. The blotches sometimes have a white centre. There is never a corresponding yellow or black, powdery pustule on the lower leaf surface.

Cercospora leaf spot (Cercospora rubi)

Cercospora infection is another very rare disease. It is identified by the presence of brownish blotches 5–7 millimetres in diameter on the upper surface of the leaf. These sometimes have a purple fringe but never a corresponding yellow or black, powdery pustule on the lower leaf surface.

Case study

Integrating biological control with chemical control methods

The problem

Chemical or physical blackberry control methods are difficult to implement in many places and impossible in others because of insufficient access to the infestation. Sections of the blackberry population regrow with vigour, and together with new seedlings and root propagules they become an ongoing and expensive problem.

The trials

Trials were conducted across eight Western Australia sites to look at the synergistic effects of using the leaf rust and the herbicide treatment most commonly used in the region (metsulfuron-methyl with Pulse®). This herbicide takes a full season to kill the plant and was applied early in the growing season so that the interaction with the rust could be monitored.

The results

Despite the rust being reared and released in a consistent way, there was a significant variation in the level of infection from site to site. The drier sites had hardly any rust, whereas in the wetter sites there was a large amount of rust present, with diseased leaves falling off and canes dying.

Herbicide control was more consistent across the sites but did not result in a 100% kill at any site. Generally, crowns and canes with new growth were killed, whereas smaller root suckers, not actively growing at the time of spraying, survived.

Rust did not develop on plants sprayed with herbicide in the same year as rust release. Although the herbicide did not kill the plant immediately, it did prevent new growth, which is essential for the establishment of the rust.

It became obvious that any potential results from combining herbicide treatment and biological control can occur only over a prolonged period of successive years. For example, the rust may infect and suppress the new growth of plants that have survived herbicide treatment in a previous year. Likewise, prior infection by the rust may weaken large blackberry plants making them more susceptible to herbicide treatment the following year.

Implications of the study

- Plants treated with herbicides will not become infected by the rust during the season of treatment.
- Integration of biological control with herbicide applications is more valuable when inaccessible areas are left untreated to allow the rust population to build up and accessible areas are treated with chemical or physical control methods.
- The rust will reduce the vigour and invasiveness of the untreated plants and minimise the reinvasion of the treated areas. It can also potentially infect any plants that have survived treatment with herbicides.

Further information on integrating herbicides with biological control can be found at **www.ento.csiro.au/weeds/blackberry/WABBManPlan2006_draft.pdf**

Case study

Integrating methods to control a range of blackberry species

The problem

Three main species of blackberry infest a 600-kilometre-long by 100-kilometre-wide area from Perth to Albany in Western Australia. Two of these are European blackberry species (*R. anglocandicans* and *R. ulmifolius*). The third is an American species (*R. laudatus*). Additional strains of the blackberry leaf rust fungus, released in the region recently may substantially reduce infestations of the European blackberry species. However, *R. ulmifolius* is only moderately affected by the rust and *R. laudatus* is not affected at all, increasing the risk that these and other rust-resistant species will replace the successfully treated *Rubus* species.

The integration of other treatment methods with biological control will be critical to achieve effective blackberry management in this region.

The approach

Mapping the locations of the various species of blackberries showed that *R. laudatus* occurred predominantly in the northern part of the region, whereas *R. anglocandicans* and *R. ulmifolius* existed over the whole region. To separate the areas of differing species and define where the various control techniques were to be used, a six kilometre blackberry-free zone was created by using the access provided by two rivers (the Brunswick and the Collie), a railway line and a road that intersected the area.

The strategy was to eradicate all infestations of *R. ulmifolius* and *R. laudatus* plants south of the line by using methods other than biological control, and to use the buffer zone to reduce seedborne spread of blackberry from the north.

What was done

Each of the 190 landholders in the buffer zone was contacted and provided with an aerial photograph of their property. Each landholder was asked to identify blackberry infestations on the photo and return it to the project group. To encourage landholder participation, herbicide was supplied for the control of minor species and outliers of major species. As a condition, the land manager had to make a long-term commitment to maintain control of blackberry after the initial treatment.

Surveillance and reporting were undertaken by a widespread network of community volunteers using the 'Weed Watcher' web-based weed reporting mechanism (**www.agric.wa.gov.au/PC_93267.html**). As a result, the current blackberry maps, which generally have recorded only the *R. fruticosus* agg. will be updated to reflect the different species present. This will allow control works to be targeted to the minor species tolerant to biological control.

Integrating control techniques

At sites where biological control was not a preferred option, Grazon® DS with Pulse® penetrant was applied at the recommended rate by high-volume hand spray, delivering approximately 2000–3000 L/ha of spray mix between October to March and ensuring very high levels of control and potential eradication wherever possible.

In areas where the use of Group I herbicides was restricted, metsulfuron-methyl + Pulse® penetrant was used at the recommended rate as above.

In sensitive areas, glyphosate + Pulse® penetrant was used at the recommended rate as above.

Mechanical control was generally used only to allow better access for spraying herbicides. However, alternative non-chemical methods need to be part of these programs to cater for organic producers or other land managers that cannot use herbicides. Although these methods are not effective at providing eradication they can prevent the production of seed and satisfy the overall aim of preventing movement of blackberry by seed dispersal.

What has been achieved

The buffer strip has been established and nearly all land managers have agreed to continue with blackberry control. Local rangers and community members are now aware that there are several species of blackberry and that identifying and reporting infestations not affected by the rust is an important community service.

The future

Blackberry is a declared plant in Western Australia, so it is possible to enforce control to maintain the initial reductions in the infestation. The increase in community awareness of the biological control program, the identification of the various species, and the willingness of land managers to target the minor species with alternative control methods will provide a lasting benefit in reducing the infestation.

Part 5

An example of blackberry management in practice

Summary

The use of an integrated approach to the management of blackberry infestations is important when dealing with the weed over large areas and jurisdictions. This part of the manual uses a case study to demonstrate how the information presented throughout the manual can be used in practice to deliver positive weed management, environmental and social outcomes.

The integrated management approach of the Genoa River Interstate Liaison Committee (GRILCO) encompasses the best practice promoted in this manual and should be considered in attempts to manage blackberry.

The relevant sections of the manual are referred to throughout this part as a guide to the information needed to make well-informed decisions regarding your blackberry management plan.

Key points:

- Integrated planning is an important component of successful control programs.
- Identifying, mapping and recording important information, as well as community education and the provision of adequate funding and resources, is vital for success.
- Involve all land managers and stakeholders within the control region to ensure all parts of the management plan are implemented.
- Monitoring, follow-up control and rehabilitation need to be ongoing to ensure good outcomes.
- Investigation of new control techniques, and their appropriate adoption, is useful to improve the effectiveness of a control program.

5.1 Introduction

The Genoa River Interstate Liaison Committee (GRILCO) is a committee comprising representatives from the East Gippsland Catchment Management Authority (CMA), Southern Rivers CMA, NSW National Parks and Wildlife Service (NPWS), the NSW Department of Primary Industries, Landcare (Snowy River and East Gippsland), Parks Victoria, the Victorian Department of Sustainability and Environment, the Victorian Department of Primary Industries, South East Fibre Exports, Willmott Forests, Bega Valley Shire Council, Bombala Shire Council and private landholders.

5.2 The problem

In 1999, GRILCO convened with the aim of controlling serious infestations of willows and blackberry in the Mallacoota Lake and the Genoa and Wallagaraugh river catchments. This area spans the eastern edge of the Victoria–NSW border. It contains the Victorian Heritage listed Genoa River and the headwaters of Croajingalong/Nadgee UNESCO World Biosphere Reserve, an international Site of Significance for Geomorphology. It also contains productive grazing and farm forestry land on Nungatta Station in NSW.

GRILCO set its first priority as the control of willows, but in 2005, with 75% of willows controlled, the group included blackberry control in its program.

Blackberry occurred throughout the catchments, affecting about 10,500 hectares. A major infestation of approximately 1670 hectares on Nungatta Station severely restricted the farm's productivity.

5.3 GRILCO's approach

At the start of the project, GRILCO defined the catchments that needed to be targeted for management attention and determined the value of each site on the basis of the assets present (e.g. productive land, conservation and heritage listed land).

For this project to be successful, GRILCO recognised that all stakeholders had to be engaged in the planning and implementation. The area crossed a State border, so agencies from both States and existing complementary project groups, as well as private landholders, had to be contacted and involved.

GRILCO identified a number of funding options for its project, including what was the Australian Government's Defeating the Weed Menace (DWM) program. To successfully apply for funding through these programs the project had to be well thought out and planned.

As well as determining the extent of the blackberry infestation problem, the group addressed the following issues:

- project coordination and on-going management
- consistent mapping to allow ongoing evaluation
- strategy development, including consideration of pathways for infestation
- contractor selection
- future rehabilitation and monitoring of control sites
- applied research and field trials to refine and demonstrate suitable techniques
- community education, awareness and involvement.

As a result of its proposed integrated plan, GRILCO secured $582,000 in 2006. This included a $215,000 grant from the DWM program for a project that would run for three years. As well, drawing-up and implementation of the plan drew on significant in-kind resources from stakeholders. Nungatta Station, for example, provided significant resources, including help with mapping, and assessment and prioritisation activities.

When beginning a blackberry control program, it is important to:

- assess the extent of the infestation and map it
- prioritise the areas for control works on the basis of the value of any assets
- identify the potential challenges involved in controlling the blackberry
- prepare an integrated management plan with a range of control techniques, clear time frames and responsibilities
- secure adequate resources to implement the plan
- engage all stakeholders.

See Part 3 (p. 28) for information on this process.

5.4 What was done

Project development, coordination and management

Project coordination and ongoing management are very important to ensure good blackberry management outcomes. GRILCO appointed a Nungatta Station subcommittee in 2006 to address that property's large blackberry infestation, agree on the mapping techniques to be used, and developed a matrix to determine how to prioritise any control works on Nungatta Station.

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Nungatta Station sub-committee in 2006.

NPWS agreed to coordinate the project and to fund a helicopter to do the mapping work (the works on Nungatta Station were coordinated by the Station).

It is important to engage stakeholders to assess an infestation and set goals for any control program (see Parts 3.2, p. 29; 3.3, p. 33 and 3.4, p. 35).

Site assessment and mapping

GRILCO assessed the known sites of blackberry infestation and developed a series of maps for use during the project. They capitalised on existing interstate agreements and utilised an existing geographical information system (GIS) to generate maps to display the locations of past and present agency activities and the extent and severity of the blackberry infestation before and after treatment, as well as to locate new infestations.

Initial mapping of a blackberry infestation is essential to allow future evaluation of the progress being made (see Part 3.2, p. 29).

The mapping exercise showed that blackberries dominated most wetlands and were present in all gullies in the Nungatta Valley. In addition, the mapping exercise showed that 700 hectares of blackberry could be controlled only by using biological or pedestrian-based chemical operations.

Undertaking a site inspection and recording key attributes of a site allows for better planning to choose appropriate control techniques, identification of the resources needed to implement the management plan, and future evaluation of control works (see Part 3.2, p. 29).

As a result of the assessment and mapping exercise GRILCO decided to target heavily infested sites in the upper catchment to protect the downstream high-conservation-value sites in the South East Forests National Park (NSW) and Coopracambra National Park (Victoria).

Prioritising sites for control by evaluating the assets present is essential for any strategic control program to achieve realistic outcomes with the resources available (see Part 3.3, p. 33).

The initial map was continually updated by the project coordinator, who receives map-based information from agencies as they carry out their respective weed control programs.

Using the same mapping techniques on a local scale allows the development of region-wide maps that show distributional patterns and allow control programs and rehabilitation to be implemented strategically (see Part 3.2, p. 29).

As part of the site assessment process, segments of blackberry floricanes and primocanes were collected for identification purposes. Samples were then identified by using the Blackberry Identification CD-ROM to determine which species were present at the priority sites. To confirm this information, samples were also sent to a herbarium for verification. The major species were *R. anglocandicans*, *R. ulmifolius* and *R. leucostachys*.

Species identification is a critical step in choosing appropriate control techniques and achieving good results (see Parts 2.2, p.22; 3.2, p.29 and 4.1, p. 39). Part 2.2 (p. 22) provides information on the key distinguishing features of blackberry and the processes available for identification. Appendix 2 provides information on how to collect blackberry specimens for identification.

Identifying pathways of invasion

Identification of pathways for infestation was an important part of the GRILCO plan. The Genoa River corridor is an invasion pathway and had a high priority for treatment to prevent infestations further downstream.

Long-term control of blackberry in this region also required simultaneous control of the key dispersers of blackberry seed (mainly foxes and pigs).

Existing pest control programs were already being undertaken in the region. GRILCO integrated these established programs into the management plan.

The mechanisms or pathways for invasion need to be considered when prioritising sites for control (see Part 3.3, p. 33).

One of the key programs was the Nungatta Fox Control Program. This is a collaborative venture between NPWS and the Bombala Livestock Health and Pest Authority to control foxes on private land in the Nungatta Valley. It is part of the NPWS Fox Threat Abatement Plan 2001.

Another key program was 'Project Deliverance'. The group running this project aims to facilitate the recovery of native mammals, birds and reptiles across approximately one million hectares of public land in far East Gippsland through the establishment of an integrated, large-scale and ongoing fox control program.

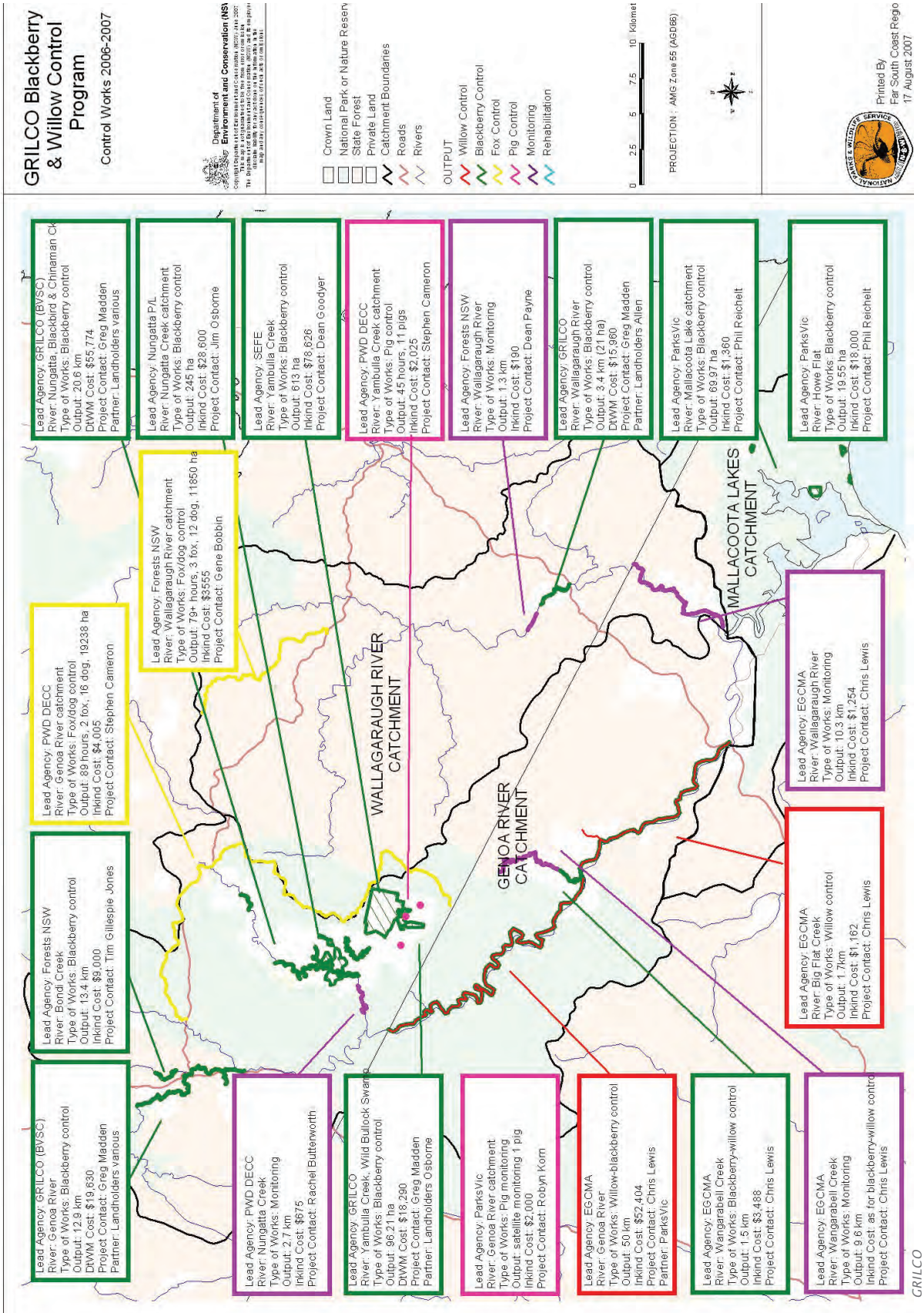
Together with the Interstate Pest Animal Working Group, these groups have developed an integrated control program using fox baiting, pig traps and collaring. Monitoring of results indicates that fox numbers on Nungatta Station have declined and pig numbers have stabilised.

Identifying the potential challenges in implementing an effective control program, such as coordination with other existing conservation programs, is very important to achieve cost-effective outcomes and to keep all stakeholders engaged in implementing the control program over time (see Part 3.2, p. 30).

Contractor selection

Contractors to undertake control works were selected on the basis of their demonstrated experience, including their adherence to relevant occupational health and safety (OH&S) practices specified by both NSW and Victorian State OH&S policies.

OH&S is always an important consideration when developing a blackberry control program. It is important to ensure that all contractors and individuals have the capacity to implement essential OH&S (see 'Safety concerns when using herbicides' in Part 4.1, p. 49).



Map produced for the blackberry control program.

Rehabilitation

A property vegetation plan was developed to provide a framework for future planning on Nungatta Station. Sites cleared of blackberries are actively rehabilitated to inhibit reinfestation with blackberry or other weeds.

Sites are planted with indigenous tree and shrub species. The emphasis is on species that will have a competitive advantage over blackberry, such as winter-germinating species.

An additional $40,000 was provided by the DWM program to fence swamps and red box communities and to carry out further vegetation monitoring.

Monitoring, follow-up treatment and rehabilitation of a control site are essential to achieve long-term blackberry control (see Part 3.6, p. 37).

Research and field trials

GRILCO worked with CSIRO to set up five trial sites for monitoring the effectiveness of the blackberry leaf rust fungus as a biological control agent. As expected, there were moderate to high infestations of the rust on the regrowth occurring at sites that had been slashed.

Field trials to compare the response of blackberry to various herbicides such as triclopyr + picloram, metsulfuron-methyl and glyphosate also commenced in January 2007.

Triclopyr + picloram showed immediate brown-off and resulted in approximately a 98% kill rate, with little regrowth evident in the following spring. Metsulfuron-methyl showed slower visible results, with continual brown-off throughout the year. Glyphosate demonstrated good brown-off, but regrowth was more apparent from root stock.

Choosing the most appropriate control methods for each site is critical to achieving good results. Integrating a range of techniques is important and takes good planning (see Parts 4.1, p. 39; 4.2, p. 57 and 4.3, p. 64).

Sites that were treated by slashing once in October 2006 and again in January 2008 showed little regrowth but substantial invasion by other species such as spear thistle. The high proportion of dead canes compared with live canes may have been the cause of the limited regrowth.

GRILCO

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Browning-off of plants after treatment with Grazon® Extra (triclopyr, picloram and aminopyralid) at different times. This field trial was established in 2007 in partnership with DOW Agrosciences.

GRILCO

Blackberry control field day in November 2006. John Campbell from MacSpred spoke on the various chemical control options and environmental outcomes.

Community action and awareness

Field days were used to raise the profile of the project and attracted large numbers of participants. They concentrated on educating the community on the chemical and biological control techniques trialled for blackberry control and on the importance of integrated fox control.

At the beginning of the project, GRILCO prepared a media strategy that outlined the key objectives and outcomes of the project. Media releases were prepared to correspond with key milestones and distributed in both States. Radio interviews have followed major media articles in newspapers. ABC's *Landline* coverage of the project, in connection with the work being undertaken by Dr Louise Morin from CSIRO, has also helped to promote the project and further community education.

Advice provided at the field days included:

- In areas close to water, use glyphosate formulated for use near water.
- A mix of picloram + triclopyr is suitable in most situations, but take care if this mix is used near eucalypts, as tree damage and death may occur.
- If eucalypts are present, triclopyr or metsulfuron-methyl can be used but metsulfuron-methyl can cause tree damage.
- Picloram, triclopyr and metsulfuron-methyl are all softer on pastures than glyphosate, allowing the retention of other species to prevent reinvasion of blackberry.
- A mixture of metsulfuron-methyl + glyphosate can be used to manage a broader spectrum of weeds growing in association with blackberry.

Determining the category of each site for blackberry control allows key actions to be identified. For example, if a site is defined as an 'exclusion zone', conducting a community awareness campaign is a priority action and an essential part of the control program (see Part 3.3, p. 33).

Works carried out and results

In one key location along Howe Flat, Parks Victoria initially decided to target an isolated three hectare infestation. They decided to foliar spray triclopyr + picloram + Pulse Penetrant® and dye included. They used backpacks and quad bikes mounted with spraypacks.

The infestation was large and dense, making access to the plants difficult. The contractors designed an innovative method to reach all parts of the plants. They laid sections of reinforced mesh over the canes, drove the quad bike onto the mesh, and sprayed both sides. They then lifted mesh from behind and laid it in front of the bike, working forward while continuing to lay and spray. The parts of the plant under the mesh that were missed were later sprayed by hand.

GRILCO

Examples of works carried out on Nungatta Station by broadacre contract sprayers.

When spraying along the Genoa River, Parks Victoria chose a different strategy. The 28 kilometre section of river that was infested was very remote, with vehicle access not possible. They needed to overcome logistical problems, such as problems communicating with contractors and the need to carry in all the necessary equipment. Again, they chose to apply herbicide by using backpack sprayers. However, in this instance they used Roundup Biactive® Herbicide™ + Pulse Penetrant®.

In both cases the kill rates of blackberry were good. This was attributed to ensuring that the blackberry was not stressed at the time of spraying. Follow-up treatment of isolated regrowth was necessary, but this was not done until there was sufficient regrowth for herbicide uptake.

The effectiveness of herbicide control programs depends on many variables, including the site, terrain and species and the condition of the plants being sprayed (see Part 4.1, p. 39).

Choosing the most appropriate herbicide (see 'Type and rate of herbicide used' in Part 4.1, p. 39) and application technique (see 'Herbicide application techniques' in Part 4.1, p. 39) also needs careful consideration before a herbicide control program is begun.

5.5 Future plans

GRILCO members agree that a number of factors have been the key to their success:

1. Involving appropriate stakeholders in the project. In 1999 they brought together a group of people with shared ideals. They continued to build on that group by expanding the network to include those who could provide more expertise and funding opportunities.
2. Effective mapping and monitoring of treated sites with consistent follow-up reporting by member agencies to allow the review of progress being made.
3. Setting realistic goals and work schedules and sticking to them.
4. Ensuring that key stakeholders, particularly agency staff, stayed involved. Agency members of GRILCO were encouraged to attend all meetings or send a replacement that had had some involvement in the project.
5. Evaluation of the control techniques that had been used, and continued use of those that had worked.
6. Maintaining the enthusiasm of everyone involved.

The project is working towards the development of best practice guidelines for the integrated management of blackberry and willows in the catchments. This has potential to be adapted to other catchments in the Southern Rivers and East Gippsland CMA regions.

GRILCO also aims to increase landholder and community awareness of blackberry and willow control techniques through its ongoing promotional and awareness-raising activities.

Part 6

Further information and Appendices

Glossary

Acronyms and abbreviations

References and further reading

Appendices

1. Noxious weed legislation for blackberry
2. Factsheet: collecting blackberry specimens for identification
3. List of State herbaria
4. Factsheet: helpsheet for using the blackberry Lucid Key
5. Field data sheet
6. Establishing photo points
7. Visual assessment of density
8. Herbicide resistance
9. Contacts for State/Territory agencies
10. Calibrating equipment to spray blackberry
11. Information on hollow-cone orifice discs for hand guns @ 14 bar (1400 kilopascals)

Glossary

Adjuvant
Any additive to a herbicide that is intended to improve the effectiveness of the herbicide.

Agricultural chemical control areas
Established in Victoria in 1996 to protect herbicide-sensitive and high-value crops. Restrictions apply to the types of herbicides, their method of application, and the periods in which the chemicals can be used.

Annual plant
Living only one growing season.

Best practice guidelines
Control protocols that seek to balance cost-effectiveness and non-target damage.

Biennial plant
Plant with a life cycle lasting two seasons.

Competency-based training
Training that develops the skills, knowledge and attitudes required to achieve competency standards.

Compound leaf
A leaf composed of a number of leaflets on a common stalk.

Containment
Restriction of the spread of an invasive species.

Control
Any method that reduces or limits damage by populations of weeds to levels that do not significantly reduce productivity.

Crown
The part of a herbaceous perennial that is just at soil level, from which roots and shoots grow.

Cultivation
Preparation of land to sow crops or pastures.

Dispersal distance
The distance a host plant can disperse seed using its dispersal mechanisms.

Efficacy
The ability of a chemical product when used according to label directions to control, kill or induce the desired action in the target pest as claimed.

Emerging species
A newly established species whose distribution and abundance is expanding.

Floricane
A cane produced by the primocane in the second year that bears fruit.

Ground cover
A cover of actively growing plants or dead material over the ground.

Habitat
The area or natural environment in which an organism or population normally lives. A habitat is made up of factors such as soil, moisture, range of temperatures, availability of light and food, and the presence of predators.

Impacts
The (usually negative) economic, environmental and/or social effects of invasive species.

Integrated weed management
A combination of control methods used for the long-term control of a weed.

Management
Defining and achieving goals while optimising the use of resources.

Native species
A species within its natural range (past and present), including the area it can reach and occupy by its own dispersal systems, even if it is seldom found there.

Naturalised
An exotic plant species that survives in competition with native animal and plant populations, reproduces, and establishes itself as a persistent part of the plant community.

Orifice disc
A hollow-cone nozzle that produces a ring of spray in a fine atomisation with a range of unique spray characteristics and properties.

Outcrossing
Mating between different individuals or species.

Outlier population
A small infestation separated by distance from a larger infestation.

Palmate leaf
A leaf that is lobed, divided or ribbed like the palm of a hand.

Perennial plant
Plant with a life cycle that lasts more than two years.

Permitted chemical
Situations often arise where chemicals are needed for a use not specified on the label. Permits issued by the APVMA allow for the legal use of chemicals in ways different from those set out on the product label. Permitted chemicals are generally used for minor use, emergency use or research.

Pinnate leaf
A compound leaf with more than three leaflets arranged in opposite pairs along the leaf stalk.

Primocane

First year cane with the ability to produce a daughter plant by touching the ground and sprouting new roots.

Public authority

1. Minister of the Crown
2. Local authority constituted by, or under, an Act
3. Government department or administrative office
4. Statutory body representing the Crown
5. Trustee or trustees of land reserved or dedicated for any public use or purpose
6. Member of staff or other person who exercises functions on behalf of any of the above.

Public land and water

Lands and water managed by public authorities.

Residual chemical

Chemical that leaves a residue that remains effective for an extended period.

Risk management

Culture, processes and structures that are directed towards realising potential opportunities whilst managing adverse effects.

Scat

Faecal material left behind by animals.

Selectivity

When a chemical affects one component of a vegetation community and the other components are unaffected.

Systemic herbicide

A chemical translocated through the plant, either from foliar application down to the roots, or from soil application up to the leaves.

Teliospore

Winter spores of a rust fungus.

Threatened

A species, population or ecological community that is either endangered, vulnerable or presumed extinct.

Tip rooting

When the tips of the arching primocanes touch the ground, sprout roots and become new plants called 'daughter plants'.

Urediniospore

Summer spore of a rust fungus.

Vegetative growth

Asexual reproduction, without seed formation.

Weed

A plant that is unwanted in a given situation and that usually has negative economic, environmental and/or social effects.

Widespread species

A widely distributed species that is having significant impacts.

Acronyms and abbreviations

ACT: Australian Capital Territory

agg.: Aggregate

ANZECC: Australian and New Zealand Environment and Conservation Council

APVMA: Australian Pesticides and Veterinary Medicines Authority

AQF: Australian Qualification Framework

BCCG: Bannister Creek Catchment Group

CMA: Catchment Management Authority

CRC: Cooperative Research Centre for Australian Weed Management

CSIRO: Commonwealth Scientific and Industrial Research Organisation

DPI: Department of Primary Industries

DST: Daylight saving time

DWM: Defeating the Weed Menace

GRILCO: Genoa River Interstate Liaison Committee

MOA: mode of action

NHMRC: National Health and Medical Research Council

NPWS: NSW National Parks and Wildlife Service

OH&S: occupational health and safety

PCL: Parks, Conservation and Lands

PPE: personal protective equipment

PTO: power-take-off

UNESCO: United Nations Educational Scientific and Cultural Organisation

WoNS: Weeds of National Significance

References and further reading

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Appendix 1

Noxious weed legislation for blackberry

Australian weed legislation focuses on the species *R. fruticosus* agg. As a result of a number of determinations, the aggregate is banned from sale across Australia. Certain States and Territories have permitted the sale of select commercial cultivars that share some genetic heritage with species in the *R. fruticosus* agg.

Commonwealth legislation

All nursery stock and seeds of the species collectively grouped as *R. fruticosus* agg. are banned from entry into Australia under the Commonwealth *Quarantine Act 1908*. Additionally, the species *R. longepedicellatus* and *Rubus* 'Brazos' and *Rubus* 'Tupi' are banned from entry. A number of commercial species and cultivars are permitted entry. The Australian Quarantine and Inspection Service ICON database at **www.aqis.gov.au/icon32/asp/ex_querycontent.asp** provides further information.

Australian Capital Territory

With the exception of the permitted cultivars listed, existing plants of any of the *R. fruticosus* agg. species must be contained, and propagation and supply is prohibited in the Australian Capital Territory under the ACT *Pest Plants and Animals Act 2005*. The permitted cultivars are 'Black Satin', 'Chehalem', 'Chester Thornless', 'Dirksen Thornless', 'Loch Ness', 'Murrindindi', 'Silvan', 'Smoothstem' and 'Thornfree'. There are no restrictions on other *Rubus* species or cultivars.

New South Wales

With the exception of the cultivars listed below, all *R. fruticosus* agg. species are Class 4 weeds under the NSW *Noxious Weeds Act 1993* throughout NSW. As a Class 4 weed, the growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority, and the plant may not be sold, propagated or knowingly distributed. The cultivars that are exempt are 'Black Satin', 'Chehalem', 'Chester Thornless', 'Dirksen Thornless', 'Loch Ness', 'Murrindindi', 'Silvan', 'Smoothstem' and 'Thornfree'. There are no restrictions on other *Rubus* species or cultivars.

Northern Territory

The species agg. *R. fruticosus* is both a Class A and C weed throughout the Northern Territory under the NT *Weeds Management Act 2001*. A Class A weed is to be eradicated if found, whereas a Class C weed is not to be introduced into the NT. As a declared weed, *R. fruticosus* agg. is restricted from sale.

Queensland

The blackberry species *R. anglocandicans* and *R. fruticosus* agg. are declared as Class 3 pests in Queensland under the Queensland *Land Protection (Pest and Stock Route Management) Act 2002*. Class 3 pests (in this case weeds) are defined as plants that have become established in Queensland and have, or could have, adverse economic, environmental or social impacts (including in other States).

It is an offence to introduce, release, give away, sell or otherwise supply a Class 3 pest. Landholders may be required to control a Class 3 pest only if it is affecting, or potentially affecting, an 'environmentally significant area' under the Act, such as a National Park.

Certain local government councils have also declared Class 3 species under local laws, requiring control in areas not adjacent to 'environmentally significant areas'.

South Australia

Excepting the listed exclusions, movement and sale of the species aggregate *R. fruticosus* is prohibited throughout South Australia under the SA *Natural Resources Management Act 2004*. This prohibition excludes any detached fruit, and also the following cultivars: 'Black Satin', 'Chester Thornless', 'Dirksen Thornless', 'Loch Ness', 'Smoothstem' and 'Thornfree'.

Control of the species aggregate is required in the following local government areas: Adelaide Hills Council, Alexandrina Council, The Barossa Council, District Council of Barunga West, Berri Barmera Council, City of Burnside, District Council of Ceduna, City of Charles Sturt, Clare and Gilbert Valleys Council, District Council of the Copper Coast, District Council of Elliston, Regional Council of Goyder, District Council of Grant, City of Holdfast Bay, Kangaroo Island Council, Kingston District Council, District Council of Le Hunte, Light Regional Council, District Council of Lower Eyre Peninsula, District Council of Loxton Waikerie, Mid Murray Council, City of Mitcham, District Council of Mount

Barker, City of Mount Gambier, District Council of Mount Remarkable, Rural City of Murray Bridge, Naracoorte Lucindale Council, Northern Areas Council, City of Onkaparinga, City of Port Adelaide Enfield, City of Port Augusta, City of Port Lincoln, Port Pirie Regional Council, City of Prospect, District Council of Renmark Paringa, District Council of Robe, District Council of Streaky Bay, District Council of Tatiara, City of Tea Tree Gully, District Council of Tumby Bay, City of Victor Harbor, Wakefield Regional Council, Wattle Range Council, District Council of Yankalilla. This requirement excludes the following cultivars when planted and maintained for domestic or commercial purposes under conditions approved by the Minister: 'Black Satin', 'Chester Thornless', 'Dirksen Thornless', 'Loch Ness', 'Smoothstem' and 'Thornfree'.

Tasmania

The species aggregate *R. fruticosus* is a declared species throughout Tasmania under the Tasmanian *Weed Management Act 1999*. Included in this species aggregate are *R. anglocandicans, R. erythrops, R. echinatus, R. laudatus, R. leucostachys, R. polyanthemus, R. vestitus, Rubus* sp. (Tasmania) and *R. laciniatus*. It does not include commercial varieties of blackberry (e.g. thornless varieties) or fruit for human consumption. Import, sale, and trade of the species are prohibited in the State. The species aggregate is a target for eradication in the municipalities of Flinders and King Island and for containment in all other municipalities. Landholders may therefore be required to manage the weed on their properties if infestations occur.

Victoria

The species aggregate *R. fruticosus* is a declared noxious weed in Victoria under the Victorian *Catchment and Land Protection Act 1994*. *R. fruticosus* is declared a regionally controlled weed in the Wimmera, Glenelg-Hopkins, North Central, Corangamite, Port Phillip and Westernport (West and East), Goulburn Broken, North East, West Gippsland and East Gippsland Catchment Management Authority (CMA) areas, and it is a Restricted weed in the Mallee CMA region.

Under the legislation, landowners must take all reasonable steps to prevent the growth and spread of regionally controlled weeds. The sale, trade, transport or display of restricted weeds is prohibited throughout the State of Victoria.

Western Australia

In Western Australia it is the responsibility of the landholder to ensure that this species is controlled to prevent seed set and spread to neighbouring properties. The legislative arrangements are currently in a transition from the *Agriculture and Related Resources Protection Act 1976* to the *Biosecurity and Agriculture Management Act 2007* (BAM Act).

The BAM Act will be implemented once the regulations and supporting documents are completed.

Under the BAM Act, it is proposed that the following *Rubus* species will be declared throughout Western Australia: *R. anglocandicans*, *R. fruticosus*, *R. laudatus*, *R. rugosus* and *R. ulmifolius*. It is likely they will be declared Class 3, Management, for the whole of the State; this will prohibit the trade, sale or movement of plants or their seeds into the State and within the State.

factsheet

Weed management:

collecting blackberry specimens for identification

blackberry identification

Floricane: the flowering stem or cane. Floricanes arise from the axils of the primocanes in the second year.

Gland: a rounded body, usually with a secretory or storage role, either sessile (sitting on the surface) or at the apex of a hair.

Herbarium: a collection of dried plants, or in the institutional sense, a building housing a collection of dried plants which are used for research and documenting the flora of a particular region.

Inflorescence: flower-bearing portion of a plant; the arrangement and insertion of the flowers determines the type of inflorescence.

Primocane: the cane or stem formed in the first year.

Voucher: a piece of plant collected, pressed and labelled which is deposited in a herbarium for confirmation of identity. Such specimens are kept by herbaria as evidence of scientific work, eg underpinning observations about distribution, rust effectiveness, weedicide effectiveness. If the identity of the plant in a scientific work is questioned the collection can be consulted.

VET sector resource: RTD2004A *Collect, prepare and preserve plant specimens.*

Blackberry CD-ROM: Purchase from - www.cbit.uq.edu.au/software/blackberry/

Background

European blackberry comprises a number of closely related plants that are often dealt with under the one name, the *Rubus fruticosus* aggregate.

At least 15 species of European blackberry have become naturalised in Australia as well as species from America and Asia. Native *Rubus* species must be distinguished from exotic species to prevent their unnecessary removal.

The effectiveness of management techniques (including biological control with the rust fungus and herbicide application) is known to vary among different European blackberry species.

Best-practice management of blackberry is therefore dependent on choosing optimal control methods after correct species identification.

An identification key for Australian *Rubus* is now available with the release of the interactive CD-ROM, *Blackberry an identification tool to introduced and native* Rubus *in Australia.*

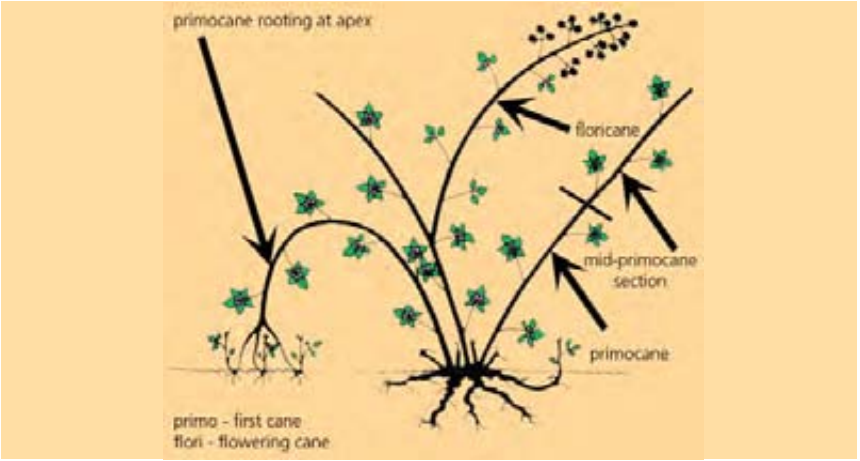
Collecting specimens for identification

It is not necessary to collect a herbarium specimen to use the blackberry key effectively. However, if quality specimens and specific information are gathered they can be made into herbarium (voucher) specimens.

Blackberry collections are surprisingly easy to make. You will need a pair of gloves, secateurs, large plastic bags, tags, pencil, esky and information sheets.

When collecting specimens for identification make sure you have:

- a section of mature mid-primocane with leaves attached – avoid young tips (see figure below);
- a piece of the flowering cane (floricane) with leaves, buds, flowers and, if available, young fruit; and
- a specimen from only one plant. Never assume there is just one blackberry species in a clump.



Caring for the specimens

Fresh samples

- Wrap specimen in newspaper and place in a sealed plastic bag with a small amount of moisture; and
- Keep cool (place in esky with ice bricks).

Plants in sealed bags can last several days in the fridge (not freezer).

Pressing for herbarium

Spread the individual leaflets out so they do not overlap and their relationship to each other is clearly visible. Place specimen in a plant press.

For further details see the Weeds CRC website's Education and Training resources:

- *Weed Collectors Manual: Collect, prepare and preserve weed specimens;* and
- Factsheet, *Weed Management - collecting and preserving plants.*

Information to collect

Use a plant identification information sheet to record relevant details, eg NSW DPI's weed identification form: www.agric.nsw.gov.au/reader/forms/

Give a precise location for each specimen, preferably a grid or GPS reference. Note elevation, extent of infestation and approximate annual rainfall. Special features to note for blackberry are listed in the table below.

For contact details of Australia's herbaria see Weeds CRC Factsheet, *Describing weeds for identification*.

Guidelines for collecting blackberry specimens

Significant features	Recommendation
Primocane *	Choose a section with mature leaves. Note whether primocane is arching or prostrate.
Floricane *	Choose a piece of floricane with the inflorescence containing buds, flowers or young fruits. Make sure the primocane and floricane are from the same plant.
Glands	Both sessile and stalked glands are found in *Rubus* and they are important in distinguishing between species. You may be able to identify them in the field if there are a lot of glands present.
Flower colour *	Check if the flower colour in the bud stays the same with age. Petals are often pink in the buds; whether they fade to white or not is a distinguishing feature.
Petals *	Check if petals are touching or not as this is significant and may be hard to see later.
Stamens and styles *	Check whether the stamens overtop the styles as this can be diagnostic in *Rubus*. This is best observed in fresh flowers. See photograph.
Fruit *	Mature fruits are very poorly documented in collections - if you don't collect the fruits, a photograph with an appropriate scale so that the fruits can be measured, would add greatly to any voucher specimen. The number of fruitlets may be useful for distinguishing between European, American and native species.
Location of plant *	Note whether the plant is growing in an open sunny position or is shaded.

*Observe these features at time of collecting specimens

For further information visit the website: www.dpi.nsw.gov.au/weeds

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Appendix 3

List of State herbaria

Australian National Herbarium

GPO Box 1600

CANBERRA ACT 2601

Phone: (02) 6246 5533

Fax: (02) 6246 5249

Website: **www.cpbr.gov.au/cpbr/herbarium**

Queensland Herbarium

Brisbane Botanic Gardens

Mt Coot-tha Road

TOOWONG QUEENSLAND 4066

Phone: (07) 3896 9326

Fax: (07) 3896 9624

Website: **www.epa.qld.gov.au/nature_conservation/plants/queensland_herbarium/**

State Herbarium of South Australia

PO Box 2732

KENT TOWN SA 5071

Phone: (08) 8222 9308

Fax: (08) 8222 9387

Website: **www.flora.sa.gov.au**

Tasmanian Herbarium

Private Bag 4

HOBART TASMANIA 7001

Phone: (03) 6226 2635

Fax: (03) 6226 7865

Website: **www.tmag.tas.gov.au/Herbarium/Herbarium2.htm**

The National Herbarium of New South Wales

Botanic Gardens Trust

Mrs Macquaries Road

SYDNEY NSW 2000

Phone: (02) 9231 8111

Fax: (02) 9251 4403

Website: **www.rbgsyd.nsw.gov.au/science/nsw_herbarium**

The National Herbarium of Victoria

Royal Botanic Gardens

Private Bag 2000

SOUTH YARRA VICTORIA 3141

Phone: (03) 9252 2300

Fax: (03) 9252 2442

Website: **www.rbg.vic.gov.au/research_and_conservation/herbarium**

The Northern Territory Herbarium

Department of Natural Resources, Environment and the Arts

PO Box 496

PALMERSTON NT 0831

Phone: (08) 8999 4516

Fax: (08) 8999 4527

Website: **www.nt.gov.au/nreta/wildlife/plants/herbarium**

Western Australian Herbarium

Locked Bag 104

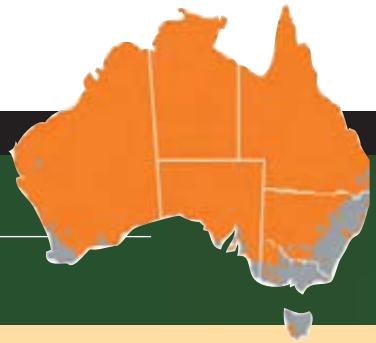
BENTLEY DELIVERY CENTRE WA 6983

Phone: (08) 9334 0500

Fax: (08) 9334 0515

Website: **www.dec.wa.gov.au/science-and-research/wa-herbarium/index.html**

Factsheet



Weed management:

helpsheet for using the blackberry Lucid Key

using the blackberry CD-ROM

VET sector resource:

RTD2004A *Collect, prepare and preserve plant specimens.*

RTC2016A *Recognise plants*

Blackberry Lucid Key: "Blackberry an identification tool to introduced and native *Rubus* in Australia" by Robyn and Bill Barker can be Purchase from - www.cbit.uq.edu.au/software/blackberry/

Helpful tips for using the CD-ROM to identify blackberry species

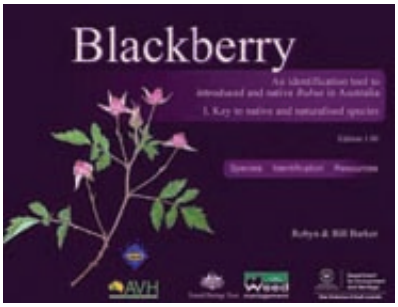
Tip	Implication
Background information	The Blackberry Lucid key was developed to assist people working with blackberry to gain a better understanding of the different types or species of blackberry, both introduced and native. Recognising these different species as an important consideration in developing and monitoring control programs. When using the Lucid key for the first time it is useful to browse through the Training slides to gain valuable background information on blackberry, the development and purpose of the Lucid Key. It is extremely useful to know that there are additional features such as a glossary of terms, links to other useful resources, information on collecting specimens and the leaf rust fungus of blackberry.
Tutorial	First time users looking at the Lucid key are advised to complete the tutorial provided to gain an understanding of the operation of the Lucid key.
Choosing a key	If you are not sure the specimen you wish to identify is from the *Rubus fruticosus* agg. choose "identify an unknown species (all native and naturalised species)" which takes you to the key for "Blackberries of Australia: native and introduced species." If you use this main key and end up with a specimen from the *Rubus fruticosus* group in the *Taxa remaining* box, you can then go to the sub-key for this group accessed through the green button to the left. If you access the sub-key this way the questions which have already been answered in using the main key will be carried across to the sub-key. One native species is included in the *Rubus fruticosus* agg. sub-key together with some of the introduced American species which are easily confused with the complex.
Home button	There is an alternate way to the sub-key if you ended up with *Rubus fruticosus* agg. You can select the "Home" button to drill down into the sub key for *Rubus fruticosus* agg. Once again, as you move from the main key to the sub-key make sure you retain the characters selected in the main key to speed up the identification process.
Choosing a character state using pictures / notes	Once you are in the key you need to focus on the *characters available* box. To look at the pictures and notes for each character state place your cursor on the purple button next to the character and click to get an image of the possible states on screen. You can make your selection of a state from here by double clicking on the picture which best matches the material you are trying to identify. To enlarge the picture click and drag it over the film projector. To read the notes about the character click and drag it over the open book symbol. Click on the brown "i" button next to each character state to get direct access to the magnified image and notes for each state. You will notice as you move characters across to the right hand *Character states* box species listed in the *Taxa remaining* box on the right will be eliminated as they are moved to the left into the *Taxa disgarded* box.
Which characters to select	When using the key, you do not need to work down the list of characters in order. Choose easily identified characters first to quickly eliminate species eg primocane stems angled or not, petal colour, leaves pinnate or palmate. To choose a character state place the arrow over the words, highlight your choice with one left click then either double click or drag and drop your choice to the right hand side. If you change your mind you can drag and drop the character back to the left again eg if you select petal colour white by mistake, instead of pink. Always check you have made the correct selection by looking at the right hand box.
Elimination of characters	It is important to note that when you select a character and move it to the right hand side it is not deleted from the list on the left. You can therefore drag and drop the character across again eg if you select petal colour- white you can still select petal colour pink by mistake. Sometimes it would be correct for more than one character state to be moved to the right hand side.

Note: the key has been developed for primocanes and floricanes at flowering although much of it applies to fruiting samples as well.

Changing the character states available	This is a feature that should be used with caution and only once you are familair with the characters and their variability and only when you have come down to a few species which can not be easily seperated. When you first open the key the default is for a set of characters called *more reliable characters*. You may not have the material ideally required eg primocane and floricane with fresh flowers. You can turn off flower charcter or fruit character if these items are not available. Sometimes characters that seem obvious such as felted under leaves are not included in the *more reliable characters* list. This is because, even though it is often seen eg on the common species *R. anglocandicans*, it is not always a distinguishing feature ie sometimes the plants of the species are not felted. To increase the available characters choose "Characters" from the tool bar and place a tick in the box next to "all". Remember - do this with caution.
Prune redundants	This option allows you to get rid of all the characters that will not separate the remaining taxa. When you use this feature you will notice characters already used will remain on the *characters available* list.
Best feature	When you choose "Character" then *Best* from the tool bar you will see that the program highlights the most useful character for distinguishing between the remaining species or taxa. If the process is repeated the next best character will be jumped to for consideration. This process will quickly eliminate species.
Similarities and difference	Once you get down to two or three species, if you can not separate them, you can choose the "Taxa" heading from the tool bar and select *similarities and differences* to help you find the characters that will allow you to separate the species.
Diagnose	When you have two taxa or species remaining you can choose "Taxa" from the tool bar then *diagnose* and you will be given a list of state(s) or characters that are uniquely diagnostic for the species. When you get "No character states uniquely diagnose this taxon from the others in Taxa Remaining" you know you have gone as far as the key will allow. Check the fact sheets to see if they shed any further light on the choices remaining. This would be a good time to consider sending a voucher to the herbaria.
Describe	The "describe" option under the "Taxa" heading gives a list of all the features of a particular species and this can be used to make a final check once you think you have correctly identified your specimen. You should also read the fact sheet for the species, particularly the *Look for* section, to see if it is describing your specimen and that the photos support your diagnosis. Checking through the *describe* list gives you more information to support your choice.
Bingo feature	Once you have cut down the number of species remaining you can quickly come to a decision by choosing "Character" then *Bingo* from the tool bar. If your specimen has a particular feature as listed choosing this feature will eliminate the others species. Always follow this up by reading the fact sheet for the remaining species and those eliminated.
Save session	If you are keying out specimens and wish to keep the list of characters chosen to come to a decision choose "key" from the main menu then *session* and give a name under which to save your choices.

Specimens to the herbaria:

The distribution of the blackberry and all its species in not well recorded because land managers are not closely observing plants and recognising that they may be a dealing with different species or they may not be aware that the species they are looking at in their location has not been sent to a herbarium for formal identification.



It is extremely important that for future research and control of this weed, more specimens are sent to the herbaria for identification.

To assit in this process obtain the CRC for Australian Weed Management fact sheet " Weed Management - collect blackberry specimens for identification" available on the Weed CRC web site.

For further information visit the website: www.dpi.nsw.gov.au/weeds

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Orange NSW 2800
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Photograph: Annette Beer

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Appendix 5

Field data sheet

ATTRIBUTE	DATA ENTRY	
Data record	Record number: (new record sheet for weed species or site)	
Name of weed	Common name:	
	Genus:	Species:
	Sub-species:	Variety:
	Hybrid:	
Day-month-year *(DD-MON-YEAR)*		
Source of data	Name:	
	Agency, employer:	
Purpose of visit		
Place name or locality	Distance and direction FROM place name:	
Map or GPS reference		
Owner of land		
Area	hectares	if transect only metres
Cover, density	Class *or*	% cover, density %
Presence of other flora, fauna		
Existing regulations, legislation or management plan		
Previous treatments		
Comments *(e.g. age/life stage, accessibility, proximity to agricultural enterprises or sensitive areas)*		
Number of records for this site*		
Land use category*		

*optional attributes
Adapted from McNaught et al., 2006 (Bureau of Rural Sciences)

Appendix 6

Establishing photo points

Establishing photo points involves marking out reference points on the ground to obtain a photo of the same area over several seasons or years.

Tips for setting up and using photo points

- Mark the location of each photo point at the site and on the site map. For example, use a star dropper or a tin-lid fixed securely into the ground and note features to allow it to be relocated.
- Use a 'camera post', 1.4–1.6 metres high, to rest the camera on. This may be the location marker if you have used a star dropper. It is important that the height is the same for each photo.
- Place another marker 10 metres from the photo point marker in the direction of the photo area. Each time a photo is taken, place a sighter pole (e.g. a star dropper) at this point and attach a label with sufficiently large writing on it so it is clear in the photo. Note an identification number and date on the label.
- If possible, align the photo direction north–south to avoid excessive sun or shadow.
- If possible, avoid steep terrain.
- Use the same camera and film type (if possible) on each occasion.
- Take photographs as frequently as necessary to reflect changes in vegetation, but make sure the photographs are taken at the same time each year to allow comparisons to be made.
- Establish enough photo points to get good coverage of the site, the vegetation present and the blackberry.

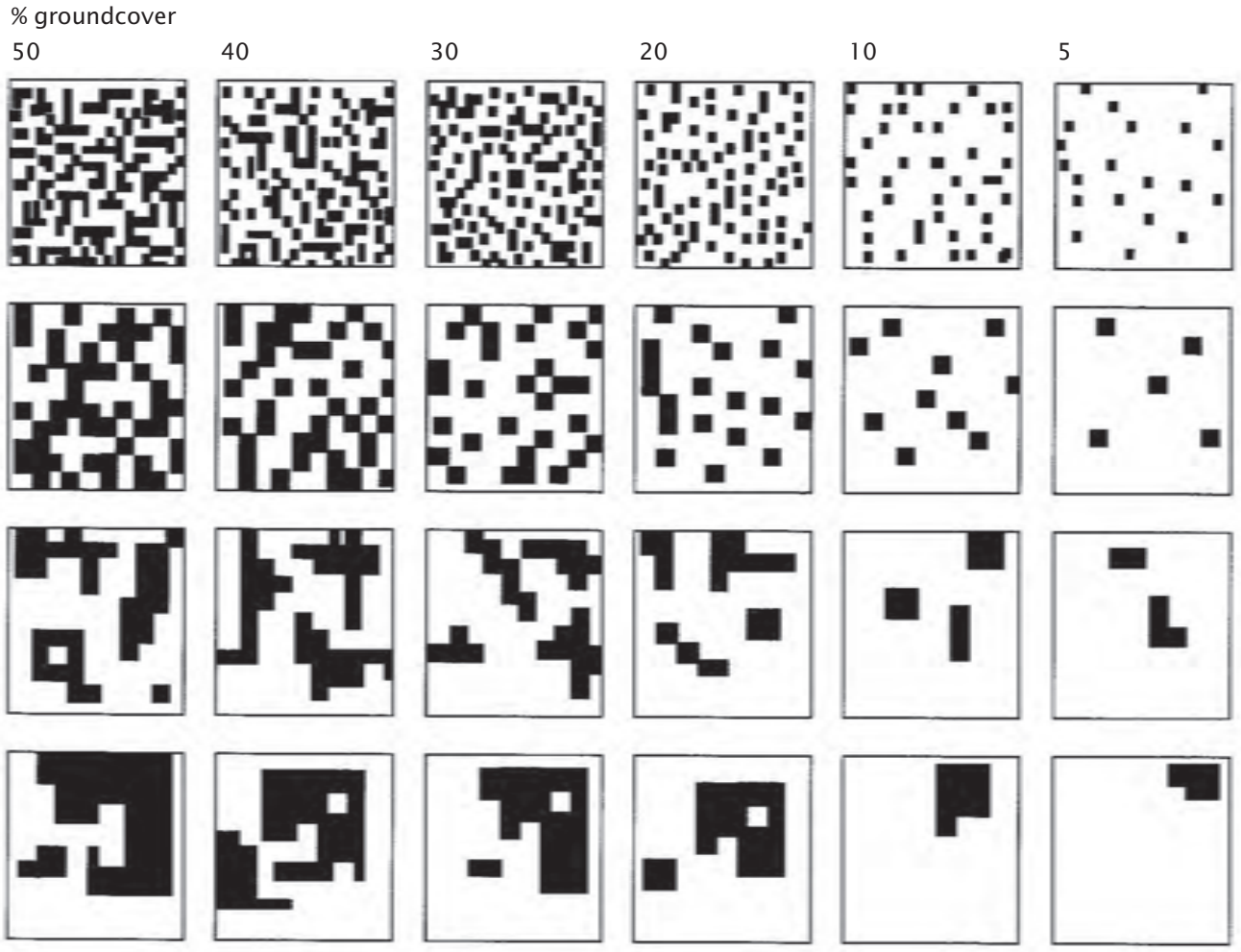
Adapted from CRC, 2003a

Appendix 7

Visual assessment of density

Visual assessment is the simplest way to determine weed density. It is quick and easy and useful for smaller sites and most species, but it can be subjective. To improve the accuracy of visual assessments please refer to the figure, which gives you an idea of how different weed densities, as a percentage of ground cover, may look. Note how dense a cover of 50% appears.

Source: CRC, 2003a



Appendix 8

Herbicide resistance

Herbicide resistance is the inherent ability of a weed to survive a herbicide that would normally control it. This is different from poor herbicide application or the natural tolerance a plant species may have to a herbicide.

If herbicide resistance develops, herbicides from a different mode of action group, or other control methods, may have to be used. These may be more expensive or less effective. Once developed, herbicide resistance may persist indefinitely unless total eradication of the infestation is achieved.

Herbicides act by interfering with specific processes in plants. This is known as the herbicide's mode of action (MOA). Different herbicides may have the same MOA.

To reduce the risk of herbicide resistance, it is important to rotate herbicides from different groups, reduce the reliance on high-risk herbicides, and use as many different control options–both chemical and non-chemical–as possible.

Table 8.1 is a summary of the herbicide groups, their associated resistance risks, and their MOAs.

Table 8.1. Summary of herbicide groups, their associated resistance risks, and their MOAs

GROUP	RISK	MODE OF ACTION
B	High	Acetolactate synthase (ALS) inhibitor
C	Moderate	Inhibitor of photosynthesis at photosystem II
F	Moderate	Inhibitor of carotenoid biosynthesis
I	Moderate	Disruptor of plant cell growth
M	Moderate	Inhibitor of EPSP synthase
Q	Moderate	Inhibitors of glutamine synthetase

Further information on herbicide resistance and its management can be found on the Crop Life Australia website **www.croplifeaustralia.org.au** or the Australian Pesticides and Veterinary Medicines Authority website **www.apvma.gov.au**

Appendix 9

Contacts for State/Territory agencies

Australian Capital Territory

Department of Territory and Municipal Services*

Phone: 13 22 81

Website: **www.tams.act.gov.au**

New South Wales

Department of Environment and Climate Change*

Phone: (02) 9995 5000

Website: **www.environment.nsw.gov.au**

Department of Primary Industries

Phone: 1800 808 095

Website: **www.dpi.nsw.gov.au**

Northern Territory

Department of Regional Development, Primary Industry, Fisheries and Resources*

Phone: (08) 8999 5511

Website: **www.nt.gov.au/d**

Department of Natural Resources, Environment, the Arts and Sport

Phone: (08) 8999 5511

Website: **www.nt.gov.au/nreta**

Queensland

Queensland Primary Industries and Fisheries* (Department of Employment, Economic Development and Innovation)

Phone: (07) 3404 6999

Website: **www.dpi.qld.gov.au**

*Agencies that mandate pesticide training

South Australia

Primary Industries and Resources SA*

Phone: (08) 8463 3000

Website: **www.pir.sa.gov.au**

Department of Water Land and Biodiversity Conservation

Phone: (08) 8463 6800

Website: **www.dwlbc.sa.gov.au**

Tasmania

Department of Primary Industries, Parks, Water and Environment*

Phone: 1300 368 550

Website: **www.dpiw.tas.gov.au**

Victoria

Department of Primary Industries*

Phone: 136 186

Website: **www.dpi.vic.gov.au**

Western Australia

Department of Agriculture and Food*

Phone: (08) 9368 3333; 1300 725 572

Website: **www.agric.wa.gov.au**

Department of Health*

Phone: 1800 022 222

Website: **www.health.wa.gov.au**

Department of Conservation and Environment

Phone: (08) 6467 5000

Website: **www.dec.wa.gov.au**

Appendix 10

Calibrating equipment to spray blackberry

Blackberry bushes are generally dome shaped; large volumes of herbicide need to be applied to wet the bush adequately.

1. Before spraying, select a bush to spray. Use Table 10.1 to assess the required spray rate. For example, a bush five metres in diameter and two metres high would need 14.9 litres of spray.
2. Spray the bush to achieve good coverage to the point of run off.
3. Time how long it took to apply the spray. If the nozzle setting was changed (e.g. from spraying stems to foliage), time each operation separately and mark when the nozzle was rotated to another setting.
4. Repeat the procedure into a bucket for the same time(s) at the same nozzle setting(s) and at the same pressure.
5. Measure the spray volume and compare this with the recommended spray or water rate determined from Table 10.1. Installing a flow meter on the high-pressure hose next to the hand gun will make calibration easier.

If spraying too much or too little, replace the orifice disc or spray nozzle, depending on the set-up. Alter the pressure only slightly for fine tuning. Big increases/decreases in pressure have only a small effect on flow rates. Big changes in pressure can affect the efficacy of the herbicide. For example, increasing the pressure produces smaller droplets that are more drift prone.

Table 10.1. Estimating the spray rate required for a domed blackberry bush

VOLUME OF SPRAY PER BUSH IN LITRES, BASED ON 3000–4000 L/Ha			
Bush diameter (m)	**Bush height (m)**		
	1.5	**2**	**2.5**
4	7	10.5	15
4.5	8.6	13.6	17.6
5	10.4	14.9	20.6
5.5	12.3	17.6	23.8
6	14.4	20.4	27.3
6.5	16.8	23.5	31.1
7	19.3	26.8	35.3

If the label specifies a spray tip or orifice disc, then the adjustment to achieve the correct volume may have to be made by spraying either faster (to reduce) or slower (to increase). If a range of tip sizes and pressures is given, then going up or down a tip size may work. If not, either speed up or slow down. For example, the instructions for use of Garlon® 600 and Grazon® DS specify a size 6–8 tip at 7–15 bar (700–1500 kPa), whereas glyphosate use instructions specify a D6 tip at 4–7 bar (400–700 kPa) and metsulfuron-methyl links tips to bush height at 5.5–7.5 bar (550–750 kPa) (size 4 or 5 tip <1 metre; size 5 or 6 tip 1–2 metres; size 7 or 8 tip 2–3 metres or large diameter).

Once the adjustment is made, repeat the procedure on another bush to check for accuracy.

Tony Cook (NSW DPI)

Dome-shaped blackberry.

Tony Cook (NSW DPI)

Hand gun with a flow meter (note that PPE is not being used because the operator is only spraying water as a demonstration).

Appendix 11

Information on hollow-cone orifice discs for hand guns @ 14 bar (1400 kilopascals)

Table 11.1. Hollow-cone orifice discs @ 14 bar (1400 kPa)

ORIFICE DISC NUMBER	PERFORMANCE	WIDE-ANGLE CONE SPRAY	STRAIGHT-STREAM SPRAY
D2	Capacity (L/min)	2.4	2.5
	Max vertical throw (m)	NA	7
	Max horizontal throw (m)	3	10.4
D4	Capacity (L/min)	5	5
	Max vertical throw (m)	NA	8.5
	Max horizontal throw (m)	3.2	11.3
D6	Capacity (L/min)	10.3	11.1
	Max vertical throw (m)	NA	10.5
	Max horizontal throw (m)	3.2	14
D8	Capacity (L/min)	16.8	18.3
	Max vertical throw (m)	NA	11.6
	Max horizontal throw (m)	3.2	14.3
D10	Capacity (L/min)	22.1	27.1
	Max vertical throw (m)	NA	12.2
	Max horizontal throw (m)	3.4	15.2

NA, not applicable.
Source: Scott and Cook, 2008