Australian Government
Department of Agriculture, Fisheries and Forestry

Weeds of National Significance

Fireweed

National best practice management manual for fireweed (*Senecio madagascariensis*)

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Weeds of National Significance
2023

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We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

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Finally, the authors would like to give special recognition to the inaugural 2012 fireweed best practice management guide produced by Brian Sindel and Michael Coleman of the University of New England. This was a seminal reference to build upon for this publication.

Foreword

In Australia, few weeds have gained greater notoriety than fireweed. This weed has also been a passion of mine since I first commenced PhD research on it over 30 years ago, but fireweed continues to be a 'burning issue' for many landholders today. Although present here from the early 1900s, fireweed was confused with similar looking native species until the 1980s when research confirmed its true identity as an introduced species from southern Africa – *Senecio madagascariensis*. Since then we have learned much about its ecology and management.

In this professionally presented publication, the authors draw on years of personal experience and expertise with weeds, as well as that of numerous scientists, advisers and land managers, to distil a wealth of information on fireweed into a comprehensive, understandable and practical guide for those contending with this invasive species.

A key part of this manual is the case studies of Australian farmers who, in a range of situations, have been attempting to control fireweed using a variety of techniques over many years. We will do well to learn from their experience, as good practice often precedes good science. Moreover, Australians are not alone in these challenges. Farmers and researchers in several countries around the world are now working to find better solutions to this problematic plant.

While it is unlikely, due to its capabilities for persistence and spread, that fireweed will be able to be eradicated from land once it becomes well established, be assured that it can be kept in check. As surveys of farmers have informed us, the elements for success will include having a plan, using a diversity of approaches and sticking at it! If utilised well, this manual will serve to help improve that level of success.

Brian Sindel, Professor of Weed Science, University of New England, Armidale, New South Wales

My first recollection of fireweed takes me back to when I was five years-old living outside Durban in South Africa, when my mother lost her horse to fireweed poisoning. It was not until some 47 years later that I again encountered this weed when we acquired a 240 acre property at Dorrigo in northern NSW. That was in 2001 and soon after, living up to its name, fireweed spread like fire across the Dorrigo Plateau.

As a noxious weed in NSW, it was incumbent upon property owners to work to control it… and work we did! In 2007 we formed Dorrigo Community Weed Action, with a special emphasis on fireweed. At the southern end of the state another group of farmers, led by Noel Watson, formed the Bega Valley Fireweed Association. Both groups worked on getting better land holder cooperation and government support for controlling the weed, including more research.

Fireweed is no longer declared in eastern NSW – the state government decided fireweed had become a reality we simply had to live with! Today our methodology to inhibit fireweed focuses on pasture improvement, mulching and zero tolerance. Whilst we're still somewhat at the mercy of the odd recalcitrant plant emerging through the pasture, they are relatively easy to pull by hand.

This updated fireweed management manual is a seriously worthwhile initiative which affords property owners the opportunity to weigh-up current, alternative strategies to deal with the weed. It is also an invaluable tool to owners who are relatively new to the land. Those of us that recognise the scourge that fireweed represents will appreciate the benefit of ensuring our neighbours have a copy of the manual. Neighbourhood relations are one of the biggest casualties of fireweed. If we can all pull together and take ownership of this weed our communities will be in a much happier place.

Rowley Beckett, land holder, 'eManzini', Dorrigo, New South Wales

Read more of Rowley and Clare's story on page 88.

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Using this manual

Who should use this manual?

This manual has been written to assist anyone with an interest in managing fireweed, *Senecio madagascariensis*, a Weed of National Significance.

The manual is focused primarily at the property scale, but the information is also relevant for a district scale fireweed control program. Reasons for managing fireweed include protecting livestock from poisoning, avoiding contamination of hay, turf or landscaping materials, and preventing seed spread between properties and along transport corridors.

The manual has drawn from both scientific studies and practical field experience to compile current knowledge on best practice management for fireweed. It will help in planning effective prevention and control measures. The manual provides source material for developing future extension materials, such as factsheets, newsletter articles and website information.

Where does the information come from?

The information in this manual has been sourced from published material, existing research, reviews by technical experts and experiences of property managers in learning to successfully suppress fireweed. Field visits in various parts of coastal New South Wales (NSW) and south-east Queensland, enabled many informative conversations. A community forum was also held at Tilba, NSW.

Whilst this manual aims to provide a synthesis of the most current information on best practice management of fireweed, it is acknowledged that this will continue to evolve. Further information will come from future research, continued development of weed control tools, and ongoing land manager observations on managing fireweed throughout its range in eastern Australia. Hopefully, biological control agents will be also become available in the future.

How to use this manual

This manual has been designed to allow easy access to all available information on managing fireweed. Arranged in five stand-alone yet complementary chapters, the manual presents a guide to the biology and impacts of fireweed (Chapter 1), how it can be prevented and controlled (Chapter 2), how to develop a property weed management plan (Chapter 3), and case study examples of how fireweed is being managed at property and regional levels (Chapter 4). Chapter 5 provides more specifics and sources of further information.

The manual has a substantial focus on preventing fireweed through establishing and maintaining dense pastures – best practice weed control is not just how to kill a weed, but also how to limit its establishment in the first place.

It is important that the information provided in this manual is adapted by individuals according to their own environmental, financial and social circumstances. Always seek local advice in planning weed control on your property.

Summary of the five chapters

1. Understanding fireweed and its impacts
- Identification
- Life cycle
- Where it grows
- Impacts

2. Preventing and controlling fireweed
- Integrated weed management (IWM)
- Preventing weed entry and spread
- Outcompeting fireweed
- Using herbicides
- Other control measures

3. Developing a weed management plan
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- Legal obligations to control
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Acronyms

See also References (Section 5.7) for other acronyms not listed below.

ACT	Australian Capital Territory
AHA	Animal Health Australia
ALA	Atlas of Living Australia
APVMA	Australian Pesticides and Veterinary Medicines Authority
CSIRO	Commonwealth Scientfic and Industrial Research Organisation
FNQ	Far North Queensland
GPS	global positioning system
IWM	integrated weed management
LLS	Local Land Services (NSW)
MLA	Meat and Livestock Australia
NRM	Natural Resources Management
NSW	New South Wales
NSW DPI	NSW Department of Primary Industries
NT	Northern Territory
NZ	New Zealand
PAs	pyrrolizidine alkaloids
PHA	Plant Health Australia
PPE	personal protective equipment
QDAF	Qld Department of Agriculture and Fisheries
Qld	Queensland
SA	South Australia
SEQ	South East Queensland
Tas	Tasmania
TRC	Tablelands Regional Council (FNQ)
Vic	Victoria
WA	Western Australia
WoNS	Weed of National Significance

Chapter 1

Understanding fireweed and its impacts

'At a glance'

- **Fireweed, *Senecio madagascariensis*, is a daisy originating from southern Africa that, in Australia, mostly grows as a cool season annual.**
- **First detected in Australia in 1918, fireweed is now widely distributed along the coast and hinterland of New South Wales (NSW) and south-eastern Queensland (Qld).**
- **It is also present in Far North Qld (FNQ), the Australian Capital Territory (ACT) and north-eastern Victoria (Vic).**
- **Most fireweed germinates in autumn and quickly commences ongoing flowering and seed set.**
- **Fireweed seed spreads rapidly—locally mainly via wind and regionally as a contaminant or 'hitchhiker'.**
- **It readily invades pastures and other open, regularly disturbed environments.**
- **Fireweed is highly toxic to cattle and horses, causing irreversible liver damage. However, it is highly unpalatable, so poisoning is rare.**
- **Sheep and goats are more tolerant of fireweed toxins and readily graze the plant.**

1.1 Description of fireweed

Key points

- **Fireweed originates from southern Africa and is now widespread in eastern NSW and south-eastern Qld. It is also present in ACT, Vic and FNQ.**
- **Fireweed has narrow, lance-shaped leaves with finely toothed to lobed edges, canary yellow daisy flowers with 13–15 'petals' and white, fluffy seedheads.**
- **There are various native and exotic weedy *Senecio* species that are similar in appearance and/or name.**

1.1.1 Name and taxonomy

Senecio madagascariensis Poir is a member of the daisy family, Asteraceae. In Australia it is commonly called 'fireweed'. However, a range of other types of plants in Australia and elsewhere, both natives and weeds, are also called fireweeds.

The species is also more specifically called Madagascan fireweed, Madagascar groundsel or Madagascar ragwort, based on its scientific name. However, its origin is more broadly southern Africa rather than just Madagascar.

1.1.2 Origin and history

Senecio madagascariensis is native to South Africa (KwaZulu-Natal, Eastern and Western Cape provinces), Eswatini (formerly Swaziland), Zimbabwe, Mozambique and Madagascar (Wijayabandara et al., 2022). The fireweed in Australia has been demonstrated genetically to have likely originated

from KwaZulu-Natal (Scott et al., 1998; Radford et al., 2000).

Fireweed was first officially recorded in Australia in 1918 at Raymond Terrace in the lower Hunter Valley of NSW, purported to have arrived in shipping ballast via Newcastle or Sydney, or in hay associated with horses imported from South Africa (Dormontt et al., 2014). It is now present to varying extents in NSW, Qld, ACT and Vic (Figure 1.1).

Fireweed was first detected at Lismore on the Far North Coast of NSW in 1940, suspected to have been introduced in contaminated crop seed. It was first reported in Qld in 1950, at Numinbah Valley in the Gold Coast hinterland. By the 1980s, fireweed had spread north and south from the Hunter and Far North Coast along coastal and hinterland NSW, and southern Qld (Hannan-Jones, 2017; Sindel and Coleman, 2012).

Since the 1980s, fireweed has spread further to the South Coast, Southern Tablelands and Northern Tablelands of NSW. Multiple incursions have been recorded in Vic since around 2012, particularly in East Gippsland and around Melbourne. Fireweed was first detected in FNQ in 2007 at Milla Milla in the Atherton Tablelands. Incursions into the ACT were first detected in 2011.

Fireweed has also invaded Hawaii, Japan and various countries in South America, including Brazil and Argentina. In addition, it has recently been confirmed to be present in northern regions of New Zealand (Schmidt-Lebuhn et al., 2022b).

WoNS
WEEDS OF NATIONAL SIGNIFICANCE

Fireweed is a Weed of National Significance

Fireweed was one of 12 additional species or groups of species added to the existing list of 20 Weeds of National Significance (WoNS) in 2012 (AWC, 2021). Fireweed was included on the WoNS list based on assessment of its invasiveness, impacts and potential for further national spread. A national fireweed strategic plan was developed, which included actions aimed at preventing and responding to new regional incursions; developing and promoting best practice management for on-property control of fireweed; and further research into biological control.

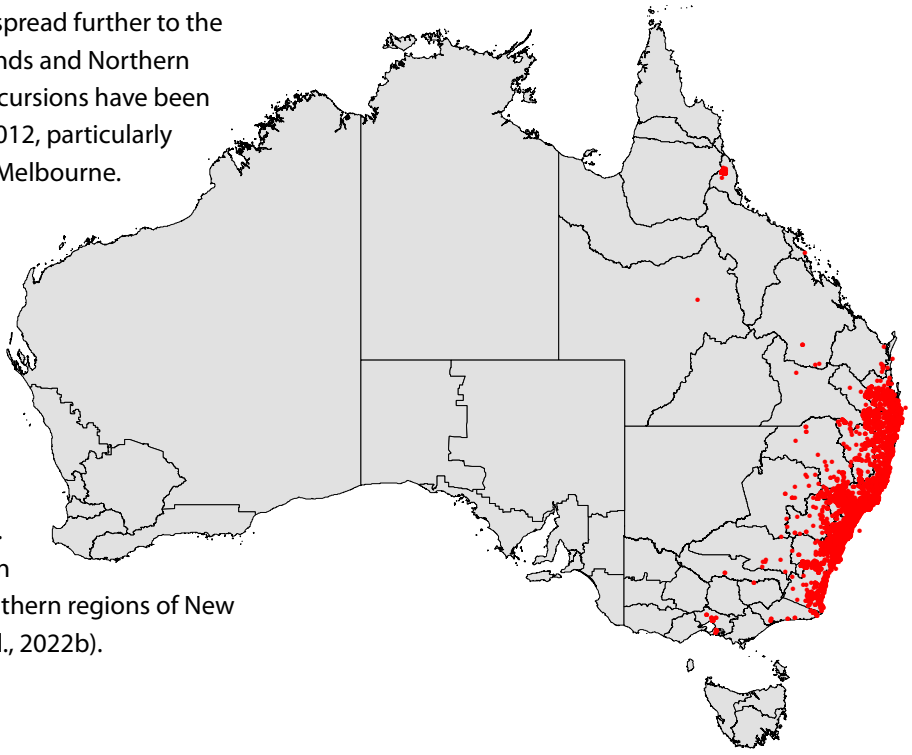


Figure 1.1 Current distribution of fireweed in Australia, by Dr Farzin Shabani from Macquarie University. Data from ALA (2022), NSW Department of Primary Industries (NSW DPI) and Tablelands Regional Council.

1.1.3 Identification

Key information sources for this section: NSW DPI (2019); QDAF (2022); Sindel and Coleman (2012); Southern Rivers CMA (2009).

Fireweed is a branching, erect, annual to short-lived perennial herb. It typically grows to 30–40 cm high but can grow up to 60 cm. Leaves are narrow and bright to dark green, with finely toothed edges and tapered, stem-clasping bases. The prominent flower heads are canary yellow and daisy like, typically with 13–15 curved ray florets ('petals'). Each seed is attached to a parachute-like pappus of fine hairs.

Further details on identifying features are provided below.

Identifying features of fireweed

Seedlings

- two opposite narrow seedling leaves (cotyledons)
- cotyledons and first true leaves often red underneath
- seedling stem also often red in colour

J.J. Dellow, NSW DPI © State of New South Wales

Seedling showing cotyledons.

John Virtue

Cotyledons and first true leaves.

John Virtue

Seedling showing red stem colouration.

Leaves

- lance-shaped leaves slightly fleshy, thin, narrow, bright to dark green and 2–7 cm long
- leaves clasp the stems at their bases
- leaves tightly packed and alternate along the stems and branches
- leaf margins slightly curved, with occasional fine toothing (small points)
- stem and major branch leaves commonly undivided, but sometimes serrated or slightly to deeply lobed
- central, pale leaf vein extending to a pointed leaf tip

John Virtue

Leaves with slightly lobed margins.

John Virtue

Leaves with serrated margins.

John Virtue

Leaves with lobed margins.

John Virtue

Leaves with toothed margins.

Stem and branches

- generally grows as an erect plant, with a woody lower stem supporting extensive branching
- lower stem can 'rest' on the ground and take root

John Virtue

Stem and branch of adult plant.

Roots

- fibrous roots branch from a central tap root
- roots 10–20 cm deep; plant easily pulled by hand
- additional roots grow from stem in moist conditions

John Virtue

Root growth from stem of adult plant.

Flowers

- up to several hundred flower heads (capitula) produced
- flowers displayed in clusters of 2–10 at the ends of branches
- small, canary yellow, daisy-like flower heads 1–2 cm in diameter
- 13–15 slightly curved ray florets ('petals'), 8–14 mm in length with rounded tips
- each flower head emerges from a green 'cup', 3–5 mm wide
- this 'cup' is made up of a single row of 20–21 green, long, narrow, vertical bracts (modified leaves called 'involucral bracts') with darkened tips
- the involucral bracts are of the same length and slightly overlap

John Virtue John Virtue

Daisy-like flower heads with curved ray florets.

John Virtue John Virtue

Involucral bracts showing dark tips (left); 'cup' (right).

Queensland Government

Flowering plant.

Seeds

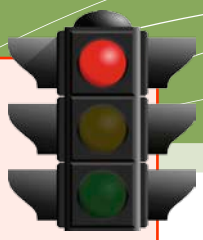
- small, cylindrical seeds ('achenes') are 1.5–2.2 mm long and 0.5 mm in diameter
- mostly light brown in colour, but some green and some dark brown
- up to 120 seeds produced per flower head
- each seed attached to a parachute-like pappus of fine, white hairs 3.5–6.5 mm long

John Virtue

Seedhead showing each seed attached to a pappus.

Brian Sindel

Differing seed colours.



Seek expert advice to confirm the identity of fireweed in a new area before undertaking any control—you may be looking at a native *Senecio*. Some differences are highlighted below but use of a botanical key is recommended for formal identification. If in Qld you can use the Queensland Herbarium's **Have I got fireweed (*Senecio madagascariensis*)?** factsheet (available at www.qld.gov.au/environment/plants-animals/plants/herbarium/weeds/weed-resources) to rule in/out fireweed (Holland 2016).

1.1.4 Not to be confused with

Senecio is one of the largest genera of flowering plants, with over 1000 species worldwide and over 150 native species or sub-species in Australia alone.

Many native *Senecio* are broadly similar in appearance to fireweed, including *S. brigalowensis*, *S. daltonii* and *S. spanomerus*. The *Senecio pinnatifolius* 'complex' (variable groundsel, native fireweed), also similar in appearance to fireweed, is found across Australia and genetic analysis indicates it is likely to be a mix of species that requires further taxonomic investigation (Schmidt-Lebuhn et al., 2022a). *Senecio brigalowensis* is native to central Qld where it is reported to cause similar poisoning in cattle to fireweed. The native *S. linearifolius* has a quite different appearance but is also called fireweed or fireweed groundsel, and is often found in disturbed areas on farms in south-eastern Australia.

Exotic, weedy *Senecio* that are also established in Australia include *S. jacobaea* (ragwort), *S. pterophorus* (African daisy, winged groundsel) and *S. vulgaris* (common groundsel). Three weedy *Senecio* not known to be in Australia are *S. inaequidens* (South African ragwort) and *S. skirrhodon*, which are very closely related to fireweed, and *S. brasiliensis* (flower of souls). These species can have livestock toxicity impacts similar to those of fireweed.

Look-a-like/similar named native Senecio

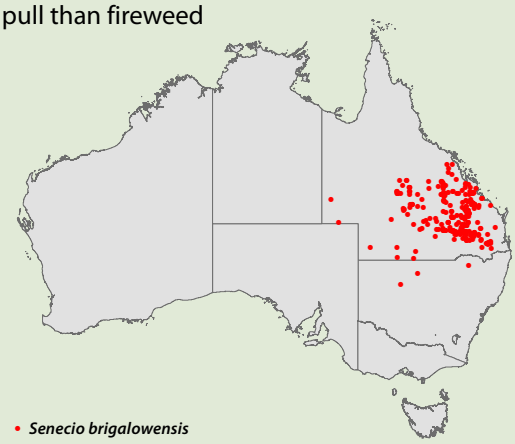
Key information sources for this section: RBG (2022); Thompson (2015). All maps provided in the section below have been sourced from www.ala.org.au

Senecio brigalowensis
brigalow fireweed, brigalow yellowtop

- annual to 0.5 m high
- found in central and western Qld, and north-western NSW

© Martin Bennett iNaturalist Australia obs. 103789130

- increasingly abundant and weedy in central Qld; toxic to cattle
- differs from fireweed by generally having narrow, divided leaves and larger seeds (achenes 2.5–3 mm long)
- has a deep taproot making it harder to hand pull than fireweed



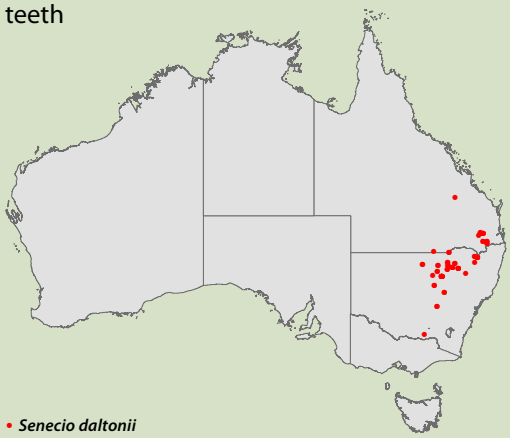
• *Senecio brigalowensis*

Senecio daltonii
Dalton weed

- perennial to 0.5 m high
- found on heavy soils west of the Great Dividing Range in south-eastern Qld and northern NSW
- weed of cultivated areas

B. A. Auld and R.W. Medd © NSW DPI

- extensive, rhizomatous root system
- 1–3 flower heads per flowering stem
- flower heads bell shaped and large (10–15 mm diameter)
- seeds 3–5 mm long
- leaves similar to fireweed: undivided with smooth margins or with a few, widely spaced teeth



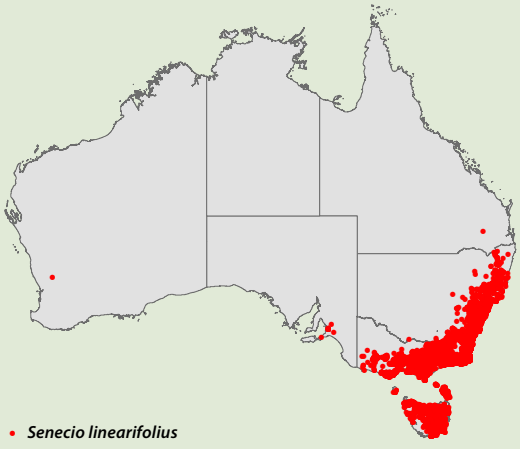
• *Senecio daltonii*

Senecio linearifolius
fireweed groundsel; also called fireweed

- perennial to >1 m high
- found in moist habitats in cooler parts of south-eastern Australia, particularly NSW, Vic and Tas

John Virtue

- upright, shrubby growth form
- 8 or fewer ray florets ('petals')
- larger leaves with conspicuous veins on upper surface, finely toothed margins that are slightly rolled under, and pale leaf undersides
- favours disturbance and often found on farms



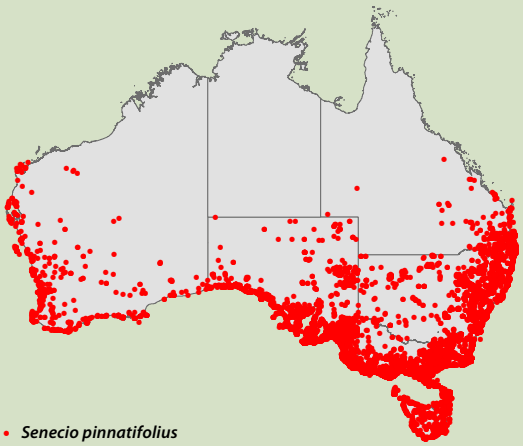
• *Senecio linearifolius*

***Senecio pinnatifolius* complex**
variable groundsel, native fireweed

- perennial or annual of variable height
- found across Australia except for the tropics
- grows in more natural habitats than does fireweed, including grasslands, forest edges, and coastal and inland dunes

John Virtue

- highly variable with many varieties; possibly different species (Schmidt-Lebuhn et al., 2022a)
- leaves undivided or variably divided
- flower heads differ from those of fireweed in generally having fewer bracts (12–21) and ray florets ('petals') (5–14)
- seeds larger than those of fireweed (achene 2.5–3 mm long)
- loose clusters of up to 25 flower heads per flowering stem



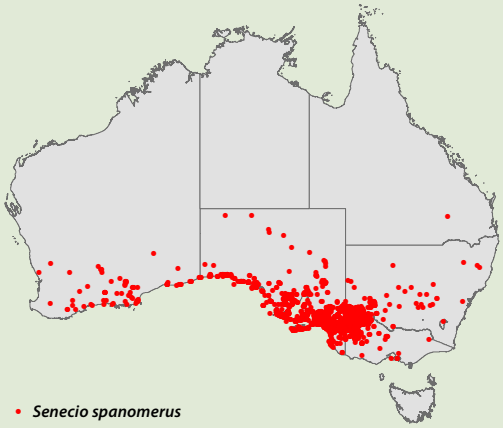
• *Senecio pinnatifolius*

Senecio spanomerus

- perennial to 1 m
- found across southern mainland Australia, particularly in south-central and south-western Australia

© M. Fagg, Australian Plant Image Index

- grows in well-drained soils of coastal dunes, rock platforms, salt lake margins, dry riverbeds and drainage lines
- similar to *S. pinnatifolius* but with narrower leaves and 8–13 ray florets ('petals')



• *Senecio spanomerus*

Other exotic, weedy Senecio *present in Australia*

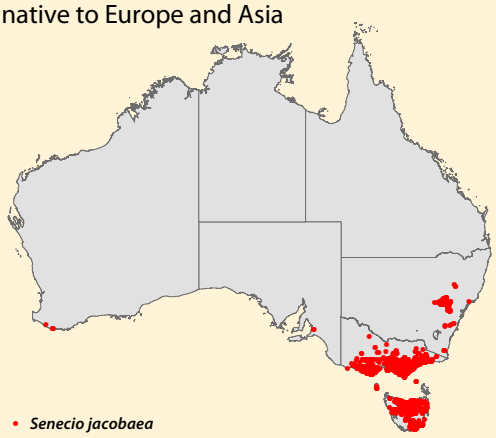
Key information source for this section: Thompson (2015).

***Senecio jacobaea* (syn. *Jacobea vulgaris*) ragwort**

- biennial or perennial up to 1.8 m high
- widespread in open and disturbed farming and natural habitats in cool, high-rainfall areas of Tas, Vic and parts of NSW

R.G. & F.J. Richardson

- forms a basal rosette (leaves radiate around the base of the stem at the ground) from which tall flowering stems grow
- flower heads all at the same level at the top of the flowering stem
- leaves deeply divided, underside lighter green and downy
- native to Europe and Asia



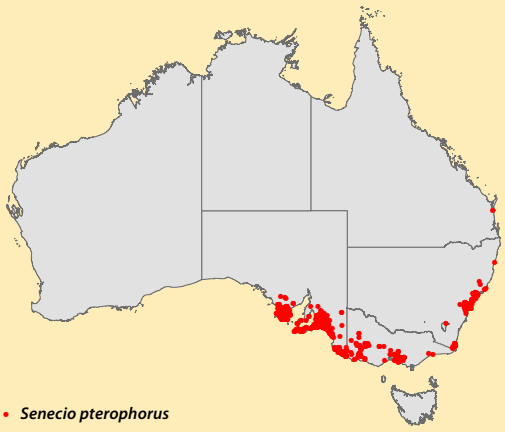
• *Senecio jacobaea*

Senecio pterophorus
African daisy, winged groundsel, rough senecio

- perennial to 1.5 m high
- widespread in open and disturbed habitats in temperate areas of South Australia (SA), Vic and central eastern NSW

John Virtue

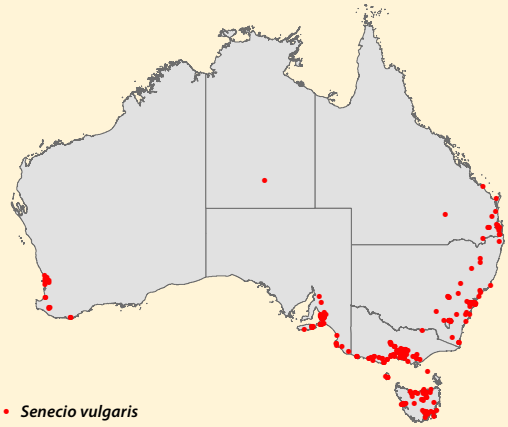
- tall, upright growth with flowers growing in clusters at the end of stems
- stems ribbed and winged
- underside of leaves whitish and downy
- native to southern Africa



• *Senecio pterophorus*

Senecio vulgaris
common groundsel

- annual to 0.5 m high
- weed of disturbed areas and cropping
- widespread in cooler areas of Australia
- flower heads with black tipped involucral bracts (a 'cup' of modified leaves at the base of flowers) and no ray florets ('petals')
- divided, sparsely hairy, fleshy leaves
- native to Europe, north Africa and Asia



• *Senecio vulgaris*

© Jon Sullivan iNaturalist Australia obs. 131499313

Exotic, weedy Senecio *not known to be present in Australia*

Key information sources for this section: CABI (2022); WFO (2022).

Senecio inaequidens
South African ragwort, narrow-leaved ragwort

- perennial to 0.6–1 m high
- very closely related to and similar in appearance to fireweed
- overlapping range in southern Africa but generally grows at higher altitudes than fireweed
- weed in Europe with toxic properties similar to those of fireweed

© Fabien Piednoir iNaturalist Australia Photo 106300439

Senecio skirrhodon
gravel groundsel

- perennial to 0.3 m high
- very closely related to and similar in appearance to fireweed
- overlapping range in southern Africa but generally grows as a seashore plant in coastal sands
- naturalised in New Zealand
- fleshy leaves

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Senecio brasiliensis
flor-das-almas (flower of souls), hempleaf ragwort

- perennial to 1–2 m high
- native to central South America
- toxic properties similar to those of fireweed
- deeply lobed, pinnate leaves with a whitish-green underside
- grooved stem

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1.2 Life cycle of fireweed

Key information sources for this section: Sindel and Coleman (2012); Sindel et al. (1998).

Key points

- **Fireweed mainly grows as a cool season annual.**
- **Autumn is the peak period for flushes of germination, but some germination also occurs in winter and spring.**
- **Flowering and seed set can be continuous from winter to early summer.**
- **Seed dispersal primarily by wind but also long distance by people (e.g. contaminated hay and machinery).**
- **Most seeds lack dormancy and germinate readily, but some will stay viable at depth in the soil for up to 10 years.**
- **Fireweed's persistence is driven by its high seed production, backed up by a long-lived soil seedbank.**

1.2.1 Germination and establishment

Fireweed germinates annually from seed, on the soil surface or buried to a depth of 2 cm (Alonso et al., 1982). Germination occurs in flushes, stimulated after significant rainfall events. Most germination flushes occur in autumn, although seeds also germinate in winter and spring (and even mid-late summer after rain).

Laboratory experiments have shown that fireweed seeds can germinate over a wide range of temperatures: 10–30°C. Levels of seed germination are increased with exposure to light. However, substantial levels of germination can also occur in darkness at cooler temperatures (<20°C) (Sindel et al., 1998; Wijayabandara, 2021).

Fireweed seed, like that of many *Senecio*, germinates in response to disturbance. Greater germination occurs when there is low ground cover (e.g. due to overgrazed pastures, late summer dry conditions or drought) and bare soils (e.g. roadsides, stock pads and tracks). The enhanced germination sensitivity to light may enable the plant to sense 'gaps' in vegetation to increase the chance of seedlings establishing. Cultivation of soil also causes a flush of germination, which may be a result of increased exposure of seeds to light and/or bringing seeds to the soil surface.

John Virtue

A flush of fireweed triggered by roadside disturbance.

Despite its common name, it is unknown how fire affects fireweed germination. Fire can stimulate germination and establishment of some plants through stimulatory chemicals from smoke and ash, and through enhanced nutrient and light levels. Although a range of native *Senecio* have a flush of germination after bushfires, it is unclear whether fireweed is also triggered to germinate.

Whilst most fireweed seeds germinate readily when exposed to suitable conditions, a small proportion (around 5–20%) have a high initial level of dormancy and will germinate in later years. Green and dark brown seeds are more dormant than the majority light brown seeds (Alonso et al., 1982).

Most seed buried in the soil loses viability after 3–5 years, but in drier environments this may extend to up to 10 years. Deeper buried seeds (down to 10 cm depth) tend to persist ungerminated for longer periods.

Fireweed is shallow rooted and germination late (or very early) in the season leaves seedlings more vulnerable to early death from moisture stress, whether from lack of follow-up rain or competition from other plants. Field research has shown that nearly half of all seedlings perish before flowering (Sindel and Michael, 1996).

John Virtue

A young fireweed plant emerging through a gap in pasture.

1.2.2 Growth

Fireweed generally grows as an annual, but given sufficient moisture it can over-summer to be a short-lived perennial. Fireweed takes advantage of moist conditions at ground level by growing additional roots along stems resting on the soil surface. It can also use other plants as physical supports to help it to grow both laterally and upwards to get more light.

With their shallow root structure, most fireweed plants die in late spring/summer because of dry soil conditions. Plants are more likely to persist in wetter areas such as drainage lines or during wet summers. Adult plants that have foliage removed such as by slashing or sub-lethal herbicide treatment can be in a better position to over-summer. Where moisture permits, regrowth can occur from the lower stem.

1.2.3 Reproduction

Fireweed typically takes 6–10 weeks from germination to first flowering. However, moisture stress has been observed to trigger flowering in small seedlings within several weeks of germination.

Once commenced, flowering is ongoing. The rate of flowering is limited by cool winter temperatures, and by lack of soil moisture reducing plant vigour. Flushes of flowering occur in autumn and spring, but flowering plants can generally be found at any time of year.

Each flower can produce 50–120 seeds, meaning individual plants can produce thousands of seeds. This scales up to millions of seeds being produced per hectare each year.

Research has shown that fireweed is an 'obligate outbreeder' in Australia; that is, to set seed it requires pollen from another plant, which is carried by insects. However, field observations in Hawaii have shown instances of self-compatibility in fireweed, where isolated plants have set seed. These observations have been supported by research showing elevated levels of inbreeding in Hawaiian populations of the weed (Le Roux et al., 2010).

John Virtue

Ongoing flowering and seeding.

Figure 1.2 summarises the typical timing of life cycle stages for fireweed in temperate and sub-tropical climates, based on NSW DPI (2012). The actual timing will vary with local climate, seasonal weather, finer-scale site conditions and management. Note that some flowering plants may be found at other times of year, particularly in warmer, wetter regions or otherwise in favourable locations such as roadside ditches. Spring germination of fireweed is more likely in sub-tropical areas and adult plants are also more likely to over-summer.

1.2.4 Seed dispersal

Fireweed seed spreads locally mainly by wind, but also as a 'hitchhiker' attached to livestock or on farm machinery. More distant regional spread can occur when seed contaminates produce such as hay or turf, or as a result of being lodged on vehicles and machinery moving long distances.

Wind

Fireweed's main method of natural seed spread is wind. Its seed is small relative to the size of the hairy pappus attached to it. The pappus is caught by the wind to carry seeds away from the parent plant.

John Virtue

Roadside cuttings provide exposed sites for seed to be blown away by wind and vehicles.

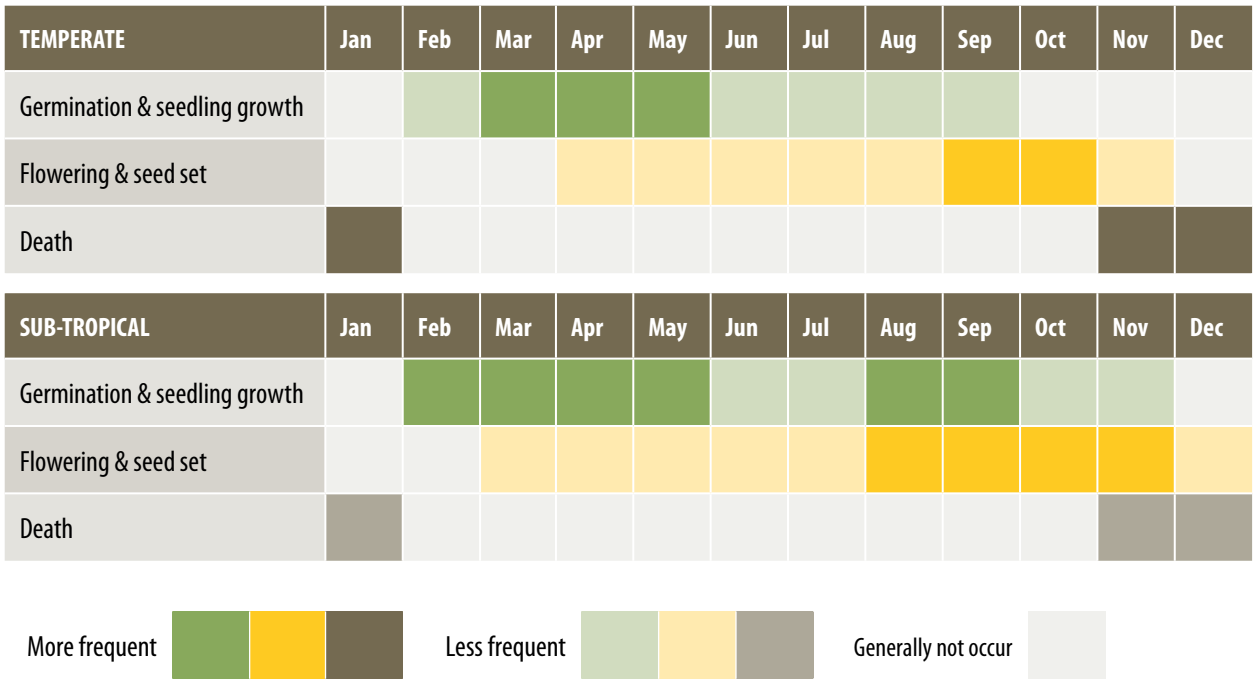


Figure 1.2 Typical timing of fireweed germination and seedling growth, flowering and seed set, and death in temperate and sub-tropical areas.

Fireweed seed has a slow settling velocity relative to other *Senecio*, meaning it floats in the air for a longer period (Mickaill et al., 2020). Wind dispersal modelling on the similar *S. inaequidens* predicted 63% of seeds would land within 10 m and 99.8% within 100 m (Monty et al., 2008). However, taking account of the high seed production per plant, the model suggested capacity for dispersal out to 200 m under common wind conditions.

Contributing factors for long-distance spread by wind include open habitats, occasional updrafts, higher elevations and windy locations (e.g. coasts, roadsides, hills and ridge lines).

Animals

The small hairs on the seeds of fireweed, plus the hairy pappus, assist them to loosely cling to the coats of animals as they move through pastures. Fireweed seed has also been observed to germinate from manure of sheep and cattle (Moxey, 2016). Potential for dispersal by these means should be kept in mind when moving livestock within and between properties. lines).

People

People may also inadvertently move fireweed seed on shoes and clothing.

Machinery and vehicles

When moving through patches of fireweed, seeds may be drawn up into radiators and crevices of utes, tractors, and other vehicles and machinery. Fireweed seed may also be present in mud and soil attached to tyres, mudguards and on soil cultivation equipment.

Mowers, mulchers and slashers present a high risk of seed spread. Cut plant material sticks on the undersides of these machines and falls off at a later time. These machines may also dislodge and locally spread seed from plants that are seeding at the time.

Many other weeds are also spread by these means—hence the importance of vehicle and machinery hygiene within and between properties, including when working on roadsides.

John Virtue

The hairy pappus enables fireweed seed to float and also lodge on vehicles and animals.

Produce contaminant, including hay and turfgrass

Cutting of fireweed-infested pasture for hay risks long-distance seed dispersal, in addition to the risk of livestock poisoning. Silage presents a lower risk as its acidic nature typically reduces weed seed viability.

Uncontrolled fireweed growing in seed crops (e.g. grain and pasture) is a contamination risk in terms of it being unintentionally planted in new regions.

Fireweed seed in turf harvested as rolls of lawn grass can lead to long-distance spread. Infestations in suburban Canberra arrived by this means, leading to a legal requirement that turf imported into the ACT must be certified as having been grown on a turf farm surrounded by a 2 km fireweed-free zone (ACT Government, 2014).

Inclusion of seeding fireweed plants when making mulches and composts may risk seed spread if it has not been subject to adequate heat and microbial decay to kill seeds. Fireweed growing adjacent to mulch piles and gravel pits risks seed contamination and movement to other sites.

Jenny Conolly, ACT Parks and Conservation Service

Fireweed contamination in laid turf.

Other means of seed spread

As with many weed seeds, fireweed seed may be washed along soil surfaces and watercourses in heavy rain and flooding events.

1.2.5 Summing up…

Fireweed's reproductive strategy appears to 'hedge its bets'. Stands of fireweed have plentiful, ongoing seed production. Most seeds lack dormancy and readily take advantage of disturbance and rainfall events to germinate. A small proportion of viable seeds remain in the soil because of dormancy and/or deep burial. This enables fireweed infestations to persist long term even if there is control of emerged plants and poor seasons for growth. The ability to form a persistent seed bank means that it is difficult to eradicate fireweed unless it is a relatively recent introduction. Even then, efficient wind dispersal from surrounding areas means that reinvasion can occur.

1.3 Environments suitable for fireweed

1.3.1 Habitat

Fireweed is most prolific in open habitats subject to regular disturbances. This includes areas where soils have been exposed by:

- intense livestock grazing or trampling
- use of non-selective herbicides
- very short mowing
- cultivation
- earthworks and landscaping.

Land uses posing particular risk are pastures and annual crops, mown or sprayed roadsides, amenity and industrial areas. In contrast, dense pastures suppress fireweed germination and establishment, though some plants can still emerge in gaps, even in tall kikuyu.

John Virtue

Fireweed favours areas of high disturbance, such as roadsides.

John Virtue

Fireweed in heavily grazed pasture.

Intact natural areas tend not to be heavily invaded by fireweed unless they are more open habitats subject to regular disturbance and of higher soil fertility. This includes riparian areas, swamp edges, degraded native grasslands and areas adjacent to tracks. Fireweed does not grow well in dense, woody vegetation where it is too shady. However, fireweed has been observed growing in such areas following clearing of the canopy, such as by bushfire.

In Australia (Figure 1.1) and elsewhere fireweed mainly grows in humid coastal, temperate and sub-tropical climates. It can also grow in the tropics at cooler, high altitudes, such as the Atherton Tablelands in FNQ. Fireweed can grow on a wide range of soils.

1.3.2 Potential distribution

Fireweed was once thought to be limited by severe winter temperatures. However, it is now established in or invading high-altitude tableland areas that experience frequent, extreme winter frosts and even snow. Frost can kill young seedlings but older established plants are more tolerant. Fireweed has invaded areas of around 1000 m in altitude; for example Tenterfield, Ebor and Nowendoc in the Northern Tablelands, Wallerawang in the Central Tablelands, and Nimmitabel in the Southern Tablelands of NSW (ALA, 2022; Jones, 2022; McIntyre, 2022).

Some records of fireweed plants in inland NSW and the ACT (Figure 1.1) have been associated with wetter areas in the landscape, including roadside drains and areas subject to supplementary irrigation such as lawns, gardens and irrigated pastures (ALA, 2022). Fireweed's shallow root system makes it vulnerable under seasonally dry conditions. However, it does

grow as a winter annual and may be able to persist in inland areas that have reliable, winter-dominant rainfall.

The predicted potential distribution of fireweed in Australia is shown in Figure 1.3, under current climatic conditions (a) and under predicted climatic conditions in 2050 (b).

Beyond the main current distribution of coastal NSW and south-eastern Qld, the model predicts suitability for fireweed establishment in both cold tableland areas and drier environments west of the Great Dividing Range. Small areas of high rainfall Tasmania (Tas), SA and WA are also predicted to be at risk of invasion. The modelling in Figure 1.3 is conservative, based on current locations of fireweed in Australia.

An alternative modelling approach, using overseas distribution data and validating it against current Australian locations of fireweed (Wijayabandara et al. 2022), has predicted even more areas of temperate, higher rainfall areas of Tas, SA and WA at risk. Expansion into western NSW, and further north along the Qld coast and central Qld was also predicted.

Implications of climate change

Figure 1.3b predicts the potential distribution of fireweed will be slightly more restricted in 2050 under higher temperatures of the SSP2-4.5 intermediate greenhouse gas emissions scenario (Riahi et al. 2017). Western NSW and Qld would be somewhat less favourable.

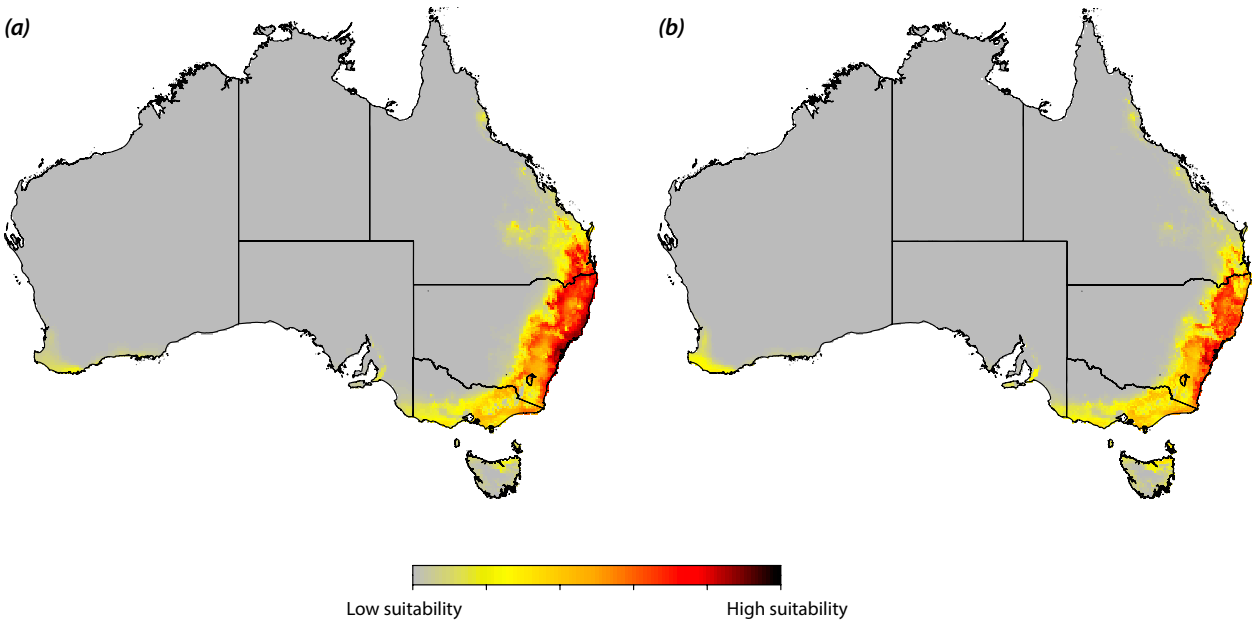


Figure 1.3 Areas of climatic suitability for fireweed under (a) current climatic conditions and (b) predicted climatic conditions in 2050 under the SSP2-4.5 climate scenario, by Dr Farzin Shabani from Macquarie University. SSP2-4.5 is an intermediate greenhouse gas emissions scenario where global carbon dioxide emissions continue around current levels until 2050, then decrease but do not reach net zero by 2100 (Riahi et al. 2017).

1.4 Impacts of fireweed

Key points

- **Fireweed contains toxic chemicals called pyrrolizidine alkaloids.**
- **Fireweed is highly toxic to cattle and horses; however, it is also highly unpalatable to them, reducing the risk of poisoning to situations where they cannot avoid eating it.**
- **Sheep and goats are much more tolerant to fireweed's toxins.**
- **The competitiveness of fireweed in pastures varies with pasture species, seasonal conditions and grazing practices.**
- **Fireweed reduces pasture utilisation as cattle and horses avoid grazing close to it.**

1.4.1 Grazing impacts

Toxicity to livestock

Key information sources for this section: Giaretta et al. (2014); NSW DPI (2012); Panziera et al. (2018); QDAF (2022); Thorne et al. (2005).

Fireweed leaves, stems, flowers and seed contain pyrrolizidine alkaloids (PAs). These chemicals can cause irreversible liver damage (chronic liver sclerosis) in livestock. Such 'Seneciosis' poisoning can cause a range of health effects from listlessness and reduced growth, to loss of weight, brain damage and sudden death from liver failure (Box 1.1), depending on whether there is low level (chronic) or acute exposure.

Box 1.1 Symptoms of fireweed poisoning in cattle and horses

Note that this is general information only. Only a vet can give a formal diagnosis.

- reduced growth rates and milk yields
- loss of condition ('ill thrift')
- loss of appetite
- weakness
- abdominal straining and chronic scouring (diarrhoea)
- skin sensitisation to sunlight (reddening and peeling)
- jaundice
- confusion, aimless wandering, poor coordination (particularly in horses, arising from brain damage)
- sudden death (including with fat cattle or after having been moved off fireweed pastures for several months)

Unknown photographer

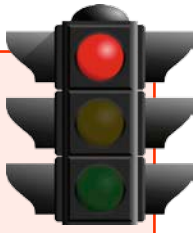
Calf thought to have fireweed poisoning.

Cattle and horses are highly susceptible to poisoning from the types of PAs found in fireweed if they eat the plant. Alpacas, donkeys, pigs and chickens are also highly susceptible (Hooper, 1978 ; Vaughan, 2018). The toxin cannot be broken down, accumulating in and causing scarring of liver tissue. Fortunately, cases of poisoning do not occur frequently as fireweed is extremely distasteful to these livestock. They avoid eating it when they can. Poisoning can occur when there is no alternative pasture or other feed available, or following slashing, or cutting for hay or silage. Cut fireweed is more palatable and is also mixed in with other forage. Young, hungry or new stock not previously exposed to fireweed are at greater risk of poisoning.

Michael Coleman

Dairy cattle in a paddock with fireweed present.

Sheep and goats are much more tolerant to the PAs in fireweed and will graze it generally with no apparent ill effect. This is thought to be because the PAs are deactivated by microorganisms in the rumen, and by liver enzymes. NSW DPI has not recorded any definitive clinical cases of fireweed poisoning in sheep or goats (Schaefer, 2023). However, a historical case was documented in sheep in the Hunter Valley by Seaman (1987) and *Senecio* toxicity in sheep has been observed in sheep in Brazil (see Section 2.7). PA poisoning can occur in sheep, for example in consuming large amounts of common heliotrope (*Heliotropium europaeum*), with liver damage by PAs



Risk factors for livestock poisoning

- **new stock unfamiliar with fireweed**
- **overgrazing of palatable pasture species leaving animals forced to eat fireweed as the only food source**
- **drought years where feed production is low and becomes more limiting over time as it gets eaten out**
- **fireweed cut in hay or silage**
- **grazing of clippings in mown paddocks containing fireweed, before pasture regrows**
- **diet high in copper (for sheep)**

increasing the risk of copper toxicity (Salmon, 2011). A precautionary approach is recommended where sheep or goats also have alternative pasture species available when grazing in paddocks with dense fireweed infestations.

Pasture competition and utilisation

Key information source for this section: Sindel and Coleman, 2012.

The competitiveness of fireweed in pastures is highly variable, and it does not consistently reduce pasture yields. Fireweed's effect on the growth of pasture plants will vary with the type of pasture, its activity in the cooler parts of the year, growing conditions (e.g. rainfall and soil fertility), grazing pressure and livestock type.

Fireweed is active in the cooler part of the year. In temperate regions, such as the South Coast and Southern Tablelands of NSW, fireweed can have a growth advantage at that time of year over warm season perennial pasture grasses such as kikuyu

John Virtue

Fireweed in cattle pasture.

John Virtue

Kikuyu left untouched by cattle avoiding eating fireweed.

(*Pennisetum clandestinum*), paspalum (*Paspalum dilatatum*) and kangaroo grass (*Themeda triandra*). Winter-active pasture grasses such as ryegrass (*Lolium* spp.) and oats offer more competition. In warmer, subtropical regions such as the North Coast of NSW and south-eastern Qld, warm season perennial pasture grasses are more competitive throughout the year.

Fireweed germinates earlier than annual clovers (*Trifolium* spp.) and can grow above and shade them. Fireweed's early growth rate is also faster than that of white clover (*T. repens*) in early winter.

Although the effect of fireweed on pasture yield may be variable, another impact is its effect on pasture availability. Cattle and horses wanting to avoid fireweed's bitter taste will leave alone pasture growing among fireweed plants, so that not all pasture is utilised. Where fireweed is at medium to high densities in pastures this considerably reduces the carrying capacity or productive potential of a pasture. Fireweed can continue to grow unimpeded through pasture as stock graze around it. Additional feed for livestock may need to be purchased if the weed is not controlled.

Loss of potential hay and silage

Pastures and fodder crops containing fireweed cannot be used to make hay or silage because of the risk of toxic contamination. There is also the risk of fireweed seed spread via hay if it is harvested when setting seed.

Costs of control in pastures

Because of the risks of poisoning and the reduced carrying capacity arising from fireweed's unpalatability, competitiveness and growth throughout much of the year, fireweed needs to be controlled in pastures. This requires an integrated approach including competitive pastures, grazing management, supplementary feeding, herbicides and/or manual removal, as detailed in Chapter 2. This represents a substantial annual management cost to properties that graze cattle, horses and other susceptible livestock.

A 2011 survey of fireweed-affected farmers in coastal and hinterland NSW and south-eastern Qld by researchers at the University of New England indicated that nearly half spent more than 50 hours and at least $1000 annually controlling fireweed (Sindel et al., 2012). A follow-up survey by the University of Queensland in 2019/20 of northern NSW and south-eastern Qld found that approximately 30% spent $200–1000 per year and a further ~20% spent $1000–5000 per year controlling fireweed on their farms (Wijayabandara, 2021).

1.4.2 Impacts on cropping

Fireweed germinates readily following cultivation in establishing crops in autumn. However, provided appropriate herbicides are used, fireweed is readily controlled along with other broad-leaved weeds and has minimal impacts on yields, as well as low risk of seed contamination. Similarly, the risk of fireweed contamination in cereal and legume fodder crops used for hay, chaff or silage is low where herbicides are used to control fireweed seedlings.

Fireweed can contaminate turf crops, growing when planted out as lawns. This can limit access to markets for affected turf farmers, and risks non-compliance where legal prohibitions apply to the movement of fireweed. For example, there is a prohibition on the import of turf into the ACT from turf farms in areas of NSW where fireweed is known to occur (ACT Government, 2014). This follows multiple incursions of the weed detected on imported turf in new housing developments.

Although fireweed may grow in horticultural crops, such as in vineyards, it is not known to have any substantial impacts.

John Virtue

Scattered fireweed in soil cultivated for cropping.

1.4.3 Impacts on people

Key information source for this section: Johnston, 2007.

The main social impact of fireweed is the time its control can take away from other farm and land management, recreation, social and community activities. Another is the social impact of tension with neighbours over differing levels of control and subsequent risks of spread between properties.

Fireweed can also take an emotional toll, including concerns over livestock health, difficulties in achieving satisfactory levels of control and the need for constant vigilance to address new incursions.

Long term, there can be perceptions of a reduction in the value of infested properties and of placing a burden on future profitability and management requirements.

Some in the community are concerned about direct human health impacts of fireweed, either through direct skin contact or consuming animal products (but noting livestock avoidance of grazing fireweed). There is no definitive scientific evidence that there are significant food safety risks posed by fireweed in Australia. Nonetheless, the broader issue of PAs and food safety continues to be examined by the Australia/New Zealand and international food standards organisations (FSANZ, 2020; WHO and FAO, 2020).

1.4.4 Environmental impacts

Fireweed is not a major environmental weed of concern with regard to biodiversity or conservation. It generally does not invade undisturbed and/or dense natural habitats such as forests, woodlands, heathlands and intact coastal dunes. However, some concerns have been raised about its potential to invade native grasslands in coastal and tablelands settings, because these are usually subject to a high level of native animal (or livestock) grazing and associated disturbance.

Observations of neighbouring populations of fireweed and the closely related *S. pinnatifolius* showed they have subtly different habitats. Fireweed tended to only grow in highly disturbed pastures, roadsides, lawns, path edges, cleared lands and river beds, and was rarely found growing in the intact native vegetation where *S. pinnatifolius* was found (Radford and Cousens, 2000).

Recent genetic studies have shown that fireweed is not closely related to Australian native *Senecio* and the risk of cross-pollination to produce adult hybrid plants is low (Schmidt-Lebuhn et al., 2022a).

Chapter 2

Preventing and controlling fireweed

'At a glance'

- **Limiting the spread, establishment and seeding of fireweed is critical for its effective control.**
- **There are various ways to prevent and control fireweed, and combining these achieves better results.**
- **Establishing and maintaining competitive pastures, or other dense groundcovers, is the key.**
- **Rotational grazing is needed to avoid overgrazing of paddocks.**
- **Grazing by sheep or goats can provide excellent fireweed suppression, but a diet very high in fireweed may pose poisoning risks.**
- **A range of herbicides are available to suit different situations.**
- **Cutting needs to be frequent to be effective.**
- **Hand removal can be effective for very small properties or where fireweed is very limited in current extent.**
- **Cultivation can control fireweed but also stimulate further germination.**
- **Mulches are only suited to amenity areas.**
- **Biological control is yet to be an option.**

2.1 Integrated weed management for fireweed

Fireweed is a challenging weed to manage, but there are various ways to control it and, better still, to prevent it. The key is increasing resilience to fireweed invasion by building and maintaining groundcover such as competitive perennial pastures. This is supplemented by biosecurity measures to limit its seed spread.

Preventing the entry and spread of fireweed seed, and limiting seedling establishment and seed production, requires a multi-pronged approach. This is called integrated weed management (IWM) and combines various control options in a strategic manner. IWM for fireweed includes:

- hygiene measures
- early detection and control of new outbreaks
- promotion and maintenance of pastures or other competing groundcovers
- carefully planned and monitored grazing, including possible use of sheep or goats
- strategic use of herbicides, and
- physical controls (cutting, hand pulling, cultivation, mulching).

Ideally, IWM would also include biological control; however, despite extensive research, no agents are yet available for use in Australia (as of May 2023).

In developing an IWM approach for your property, consider the advantages, disadvantages and timing of fireweed prevention and control methods available. These methods are summarised in Table 2.1, and each is described in this chapter. Examples of

IWM approaches are presented in the property case studies in Chapter 4.

There is no single IWM 'recipe' to be adopted by all properties. IWM should be tailored according to fireweed burden, property type and management goals, environmental conditions (e.g. climate, soil type, other plant species present), financial and technical capacity, broader biosecurity needs and other land management issues and opportunities. IWM also needs to take a multi-weed species approach because there are often other important weeds also present.

The management challenges of fireweed

- It produces high numbers of seeds over long periods.
- Seeds disperse efficiently by many means, including wind, as a produce contaminant (e.g. hay), on machinery (e.g. slashers) and livestock.
- Seed can remain viable in the soil for years.
- Seeds readily germinate on exposed soil following heavy grazing and other disturbances.
- Fireweed is avoided by cattle and horses, giving it a competitive advantage in pastures.

These features of fireweed mean that complete eradication is extremely difficult and time-consuming to achieve unless it is caught at a very early stage and there are no nearby infestations. In areas where fireweed is widely established, ongoing management using a range of control and pasture management methods is required to keep fireweed density low.

John Virture

Table 2.1 Summary of fireweed prevention and control measures. Note that biocontrol is in *grey italics* as its inclusion in fireweed IWM is pending any biological agents becoming available in future years.

	Advantages	Disadvantages	Caution!	Timing	Integrate with
Property biosecurity	▪ Prevents weed entry and spread ▪ Avoids future costs and impacts ▪ Low ongoing cost	▪ Setup costs for washdown areas ▪ Ongoing time commitment to manage spread pathways ▪ Ongoing effort needed to obtain everyone's compliance	▪ Difficult to limit natural pathways of spread – particularly wind	▪ Year-round	▪ All on-property activities ▪ All other fireweed control measures
Surveillance	▪ Early detection and intervention reduces impacts and costs	▪ Searching is time-consuming and ongoing (every 2–4 weeks)	▪ Difficult to detect fireweed until it is flowering, by which time it may have set seed	▪ Autumn–spring ▪ May be occasional plants in summer in wetter areas	▪ All other fireweed control measures
Competitive pasture	▪ Limits fireweed germination and establishment ▪ Can increase livestock grazing capacity and farm profits ▪ Suppresses other weeds and protects soil from erosion	▪ High upfront establishment costs ▪ Need for ongoing, careful pasture management, including rotational grazing ▪ Fireweed plants may still grow, albeit at a low density	▪ Seek professional advice on establishing locally adapted pasture species and a sustainable grazing system ▪ Need to manage fireweed at pasture establishment phase	▪ Year-round ▪ Focus on having dense cover leading into autumn	▪ Biosecurity ▪ Surveillance ▪ Sheep/goat grazing ▪ Herbicides ▪ Cutting ▪ Hand removal
Sheep/goat grazing	▪ Can substantially reduce fireweed density ▪ Can integrate with cattle enterprises ▪ Reduces need for herbicidal control	▪ Cost of fencing and other infrastructure requirements ▪ Ongoing health and welfare requirements ▪ Ongoing marketing needs of animals and their products	▪ While much more tolerant than cattle or horses, sheep and goats may still be poisoned by very high intake of fireweed	▪ Year-round	▪ Biosecurity ▪ Competitive pasture
Herbicide application	▪ Can enable targeted control of fireweed ▪ Quick to apply to multiple plants ▪ Range of herbicides to suit different situations	▪ Long withholding periods for some herbicides ▪ Risk of off-target effects on desirable plants ▪ Risk of spray drift and environmental contamination	▪ Various legal requirements apply when using herbicides ▪ Follow safety directions ▪ Follow directions on managing drift and residue risks	▪ Most effective boom sprayed on seedlings in autumn–winter ▪ Spot spraying at other times of year	▪ Biosecurity ▪ Competitive pasture ▪ Soil cultivation ▪ Hand removal

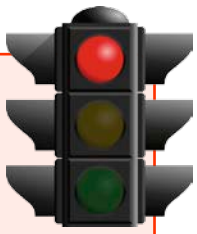
Table continued on next page/. . .

	Advantages	Disadvantages	Caution!	Timing	Integrate with
Cutting	▪ Can control fireweed if done frequently ▪ Can stimulate vigorous pasture grass regrowth, depending on species and timing ▪ Applicable to domestic and amenity situations (e.g. mown lawns)	▪ Cut fireweed can regrow, requiring further treatment ▪ Risk of spreading seed ▪ Cut fireweed remains toxic and stock cannot avoid eating it in clippings	▪ Machinery hygiene required to minimise risk of spreading weed seeds ▪ Cannot use pastures containing fireweed for hay or silage ▪ Cannot graze until cut fireweed is decomposed	▪ Winter–spring for cool season pasture grasses, mid-spring for warm season grasses ▪ Avoid seeding fireweed ▪ Avoid cutting in late spring to reduce risk of over-summering of fireweed ▪ Multiple passes needed	▪ Biosecurity ▪ Competitive pasture ▪ Sheep/goat grazing ▪ Herbicides
Hand removal	▪ Low cost ▪ Suitable for early intervention where there are small infestations ▪ Minimal environmental impact ▪ Good for 'mopping-up' after other controls	▪ Need to locate all individual plants before seed set ▪ Time-consuming and labour intensive ▪ Generally not practical for large infestations and properties	▪ Wear gloves ▪ Take precautions to avoid strain injuries	▪ Year-round	▪ Biosecurity ▪ Surveillance ▪ Competitive pasture ▪ Herbicides
Soil cultivation	▪ Non-chemical means of controlling fireweed seedlings ▪ Suitable for gardens ▪ May be used in pasture establishment	▪ Promotes fireweed germination, requiring further control ▪ Risk of soil erosion and damage to soil structure ▪ Risk of fireweed regrowth in moist soils ▪ Cost of machinery	▪ Frequent cultivations can damage soils and expose them to erosion	▪ Autumn–winter for fireweed seedlings	▪ Biosecurity ▪ Surveillance ▪ Competitive pasture ▪ Herbicides
Mulches	▪ Suitable for gardens and amenity areas	▪ Fireweed seed may blow onto and then grow in mulch ▪ Cost of materials ▪ Risk of weed seed contamination in certain mulches ▪ Not practical for use across large areas	▪ Remove existing weeds before applying to the soil surface and any weeds that grow in the mulch ▪ Take precautions to avoid strain injuries	▪ Any time	▪ Biosecurity ▪ Surveillance ▪ Herbicides ▪ Hand removal ▪ Soil cultivation
Biocontrol	▪ *Potential to reduce growth and reproduction of fireweed* ▪ *Self-sustaining*	▪ *Not an eradication tool – unlikely to give sufficient control on its own*	▪ *A potential biological control agent cannot be released where it poses an unacceptable risk to non-target plants*	▪ *An agent would be active at certain times of year according to its life cycle*	▪ *All other fireweed control measures*

2.2 Preventing weed entry and movement

Key points

- **Fireweed and other weeds may be brought to and spread within a property in many ways.**
- **Ensure vehicles, machinery and equipment arrive and depart clean.**
- **Establish a dedicated clean-down area.**
- **Quarantine livestock on arrival.**



Legal requirements to control fireweed

In certain parts of Australia you may be legally required to take measures to prevent the spread of fireweed – such as avoiding fireweed seed contaminating produce (e.g. hay, turf). You may also be required to control fireweed infestations on your property.

Section 5.1 lists the current declaration status of fireweed (as of May 2023) in each state and territory. Contact your local weed management authority for further information in relation to your location.

2.2.1 Biosecurity and property hygiene

Key information source for this section: AHA and PHA (2022).

Biosecurity at the property level involves measures to prevent the entry, spread and establishment of new weeds, pests and diseases. It also applies to not 'exporting' weeds, pests and diseases from your property to other properties (e.g. through contaminated produce or machinery). Developing and routinely implementing a property biosecurity plan is a valuable, low-cost investment to prevent and lessen incursions of a wide range of weeds and other pests and diseases.

Guidance on property biosecurity planning is available on the **Farm Biosecurity website** (www.farmbiosecurity.com.au/) and from other government and industry sources (see Section 5.6). A biosecurity plan considers the pathways for how pests, weeds and diseases can enter, spread within and move off a property. For fireweed, various biosecurity practices can be implemented to prevent the movement of seed to and across the property.

Fodder and seed

Historically, fireweed is thought to have moved into some districts via contaminated hay or crop and pasture seed. This can be a common means of spread for many weeds, and the risk increases in times of widespread feed shortages, such as during droughts or following bushfires or floods.

- Only purchase weed-free hay and other livestock feed such as grains. Where possible, determine where fodder has come from and ask for a vendor declaration, such as the Australian Fodder Industry Association's **Fodder Vendor Declaration Form** (www.afia.org.au).
- Feed out fodder to livestock in set areas where you can check regularly for new weeds.
- Ensure pasture and crop seed has been cleaned and certified free of weed seeds.
- Do not make hay or silage in paddocks infested with fireweed.

AFIA
Australian Fodder Industry Association

Fodder Vendor Declaration Form

VDF No.: _____
Contract No. _____

1. Vendor's Details	**2. Buyer's Details**
Vendor's name:	Buyer's name:
Address:	Address:
Tel: Fax:	Tel: Fax:
3. Production Details If vendor not the producer, provide corresponding producer's VDF No.	
Paddock identification:	Delivery date:
Commodity:	Cutting date:
Is 95% free of genetically modified organisms: **Yes** ☐ **No** ☐	Other:
4. Fodder Quality	Analysis: Lab Reference no.:
Product description:	Dry matter: %
Species:	Crude protein: % of DM
(if mixed include estimate of percentage)	Metabolisable energy: MJ/kg of DM
Quantity: Bale size:	Other:

5. Weeds Biosecurity

Is it likely that this fodder contains weed material / seeds? **Yes** ☐ **No** ☐

If Yes, please list what weed species may be present:

_____ _____ _____ _____ _____

6. Testing and Chemical Status

This form only applies to a single "lot" of hay (see Sampling Protocol on pressure sheet)

Has the fodder sample been taken according to AFIA Sampling procedure? *(one test per 200 tonne lot or paddock)* **Yes** ☐ **No** ☐

Has the fodder been tested for ARGT **Yes** ☐ **No** ☐

or Prussic acid? **Yes** ☐ **No** ☐

If yes name, the Laboratory..... Case or Sample No..... and Result .....

Has the fodder been tested for pesticide residues? **Yes** ☐ **No** ☐

If yes, attach details of testing results on the delivered product

Has the crop been grown on a property with either an organochlorine (OC) status classification, or under quarantine because of OC residues, within the past 12 months? *If yes give details* **Yes** ☐ **No** ☐ **Do not know** ☐

Does the property from where the fodder is grown carry accreditation under an independently audited QA program? **Yes** ☐ **No** ☐

If yes give name of program

Has the fodder crop been subject to spray drift during its production? **Yes** ☐ **No** ☐ **Do not know** ☐

If yes attach a list of chemicals applied to neighbouring crops, the date sprayed and application rates.

If selling fodder to a client, operating within a livestock QA program, who require a full list of chemical names, rates and dates both applied to the fodder crop, as well as those applied to neighbouring crops within 100 metres, please attach the details to this form.

6 Declaration

I/We .....(name of fodder supplier)

declare that I/we have the systems in place to ensure that the fodder complies with all State and Federal laws and the requirements relating to chemical and pesticide residues and specified Government designated maximum residue levels. These systems include:

(i) any chemical treatment applied to any component of this consignment during storage on our premises or otherwise in our possession was applied as per product label approved by the National Registration Authority for Agriculture and Veterinary Chemicals and that the withholding period specified on that label has been observed; and

(ii) In relation to the sourcing of raw materials:

a) the property on which the fodder was grown, or the storage facility in which the fodder has been stored, carries accreditation under a recognised, and independently audited QA program, which includes chemical residue management provision, **OR**

b) has been purchased under a contract in which the supplier warrants that the fodder complies with all State and Federal laws and requirements relating to chemical and pesticide residues and specified Government designated maximum residue levels, **OR**

c) in relation to direct farm purchases that the supplier of the fodder has attested to the effect that any pesticides/insecticides used on the fodder have been applied in accordance with the registered labels of these chemicals, at rates not exceeding the maximum rate set out on the label of these chemicals and the appropriate withholding periods have been observed.

I/we further declare that this consignment at the time of the sale:

1. Is free from animal material as defined and required under State legislation and
2. It is otherwise fit for the purpose of feeding to the category of livestock indicated in the product description above.

Intended Use/Purpose: .....

VENDOR'S SIGNATURE_____ **DATE**_____

* AFIA Ltd does not accept responsibility or any liability for the information contained in this declaration. January 2017

An example fodder vendor declaration form (used with permission Australian Fodder Industry Association).

Sandy Carter

Feed out hay in the same area.

Sandy Carter

Tractor tyres cleaned of mud.

Vehicles, machinery and equipment

Fireweed and other weed seeds may lodge in or on vehicles, machinery and other equipment when used in paddocks, on roadsides or other infested areas. Weed propagules can also be picked up in mud. A range of measures can be put in place to reduce the spread of weeds.

- Limit where vehicles that come onto your property can go. Install biosecurity signage advising drivers to stay on tracks and park in designated areas, or to stay out of paddocks.
- Clean vehicles, machinery, equipment and tools with a high pressure wash/blow down at a designated site, on exiting a known infestation area and before entering clean properties. Mud in tyres, on mudguards, and soil cultivation and excavation equipment poses a high risk for spreading weed seeds. The clean-down site should be frequently inspected for weeds. Soil and plant residue from cleaning should be collected for disposal. Biosecurity Queensland has a comprehensive **guide for vehicle and machinery clean-down** available at www.daf.qld.gov.au/__data/assets/pdf_file/0011/58178/cleandown-procedures.pdf (Biosecurity Queensland, 2019).
- Because slashers and mowers collect and spread weed seeds along roadsides, in parks and in paddocks, slash or mow from the least to most weed-infested areas. Avoid times when weeds are flowering and seeding if possible. Wash down or blow down equipment and machinery before moving to new areas.
- Ensure farm equipment and tools that you loan to or borrow from neighbours are clean before they leave each property.
- Avoid driving through patches of flowering fireweed because seed can be drawn up into radiators and vents and through open vehicle windows, and mud and manure can stick to tyres, mudflaps and wheel arches (Johnston, 2007).
- Monitor farm infrastructure and storage areas (e.g. fence lines, tanks, sheds, livestock yards, irrigation infrastructure) that may act as refuges for weeds such as fireweed, and control weeds here.

People

Biosecurity is about managing people's behaviours and actions.

- Install biosecurity signage at entry points to ensure visitors are aware of your biosecurity expectations, including what they should do to minimise risks.
- Brush off weeds that can attach to footwear and clothing before entering fireweed-free areas. Mud on footwear should be removed with boot scrapers and brushes.

Livestock

Farm animals can carry weed seeds externally, lodged in coats, wool and hooves. Many weeds can also be dispersed internally if they pass through the digestive system. Viable fireweed seed has been detected in both cattle and sheep manure (Moxey, 2016).

- Visually inspect stock for attached weed seeds before transporting them to and from your property.
- Request a vendor declaration stating what weeds are known or not known to be present on the property from which the livestock originates.
- Quarantine stock in a defined area on arrival for 10 days to allow time for weed seeds to be excreted. This is also important from an animal health perspective to detect and isolate animals posing disease risks. Monitor this area seasonally for at least two years to detect any new weeds.
- Record which paddocks newly introduced livestock are placed in. Focus on these for routine inspections to detect any new fireweed or other weed incursions.
- Maintain fencing between properties to prevent stock movement.

Fertilisers, composts and manures

These products are broadcast across paddocks, and hence their cleanliness from weed seeds is vital.

- Follow industry standards in the production of processed animal manures and composts to reduce risks of weed seed contamination. Buyers should ensure these standards have been followed (e.g. via certification) when purchasing these products.
- Cover (where possible) stored or stockpiled fertilisers, manures and composts and keep the area weed free.

Landscaping supplies

Gravel, sand, topsoil and mulches for use in road building, earthworks and landscaping are known sources of weed propagules. Turf is also known to carry a risk of introducing fireweed (ACT Government, 2014).

- Where possible, source landscaping supplies from weed-free areas and check that vendors keep their bulk storage sites weed free.
- Seek a vendor declaration stating purchased turf is free of fireweed.

See also '*Fireweed and turf production*' box on next page.

Natural spread

Spread by wind, water and wild animals is more difficult to manage, but should still be considered in seeking to prevent new weeds arriving and spreading on your property. Wind dispersal is the main mechanism of local spread of fireweed.

- Consider windbreaks around property edges and within (e.g. around paddock boundaries), which can reduce the distance that wind-borne weed seeds may spread, and even capture and concentrate seed fall.

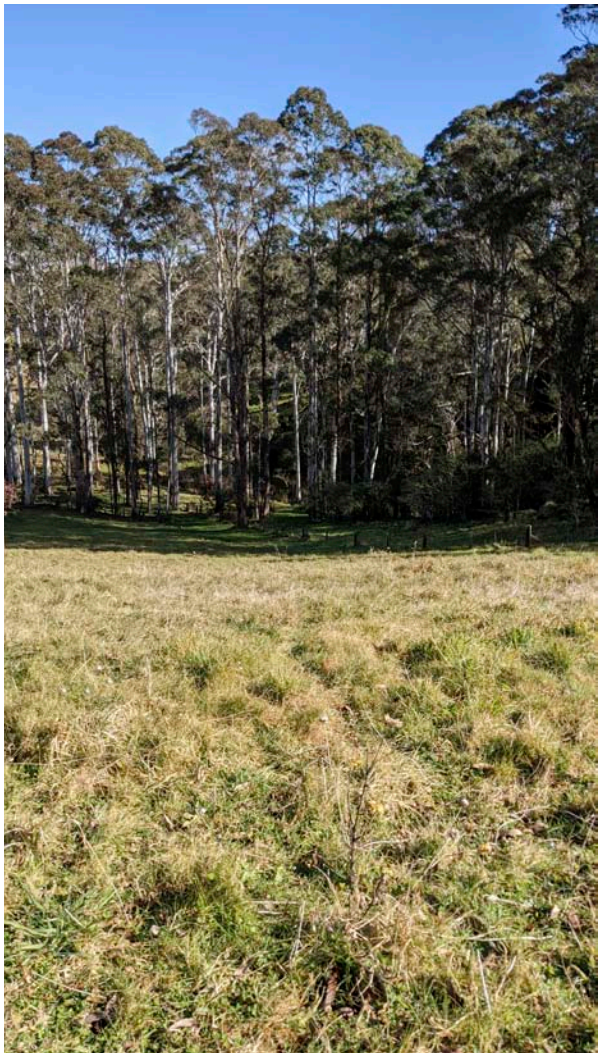
Fireweed and turf production

Incursions of fireweed into the ACT as a contaminant of laid turf led to legal requirements for products supplied in the territory to be fireweed free (ACT Government, 2014).

A weed management system of a weed-free seedbed, pre-emergent herbicides and regular mowing controls a wide range of broadleaf weeds on turf farms, including fireweed. Nonetheless, fireweed seed may still blow in from surrounding properties and settle on turf – hence, a further preventative measure is application of pre-emergent herbicide just prior to delivery.

Turf should be purchased from certified/ accredited producers that have been audited to meet production quality standards, including for weed control practices.

Megan Ford, AusGAP



John Virtue

A tree windbreak can slow fireweed movement.

- Inspect property fences and other physical obstructions where wind-borne weed seeds may have dropped and established.
- Find which parts of your property tend to be more prone to fireweed invasion due to local wind movements and topography. Inspect these more often.
- Monitor areas that feral and native animals frequent because they may introduce weeds.
- Bear in mind that watercourses may be an occasional pathway of spread for fireweed.

2.3 Finding and removing new fireweed outbreaks

Key points

- **Fortnightly to monthly searching is needed to detect and remove fireweed plants before flowering.**
- **Focus on areas that are a high risk for fireweed incursions.**
- **Record locations where fireweed is found in order to check again in future searches.**

In addition to hygiene measures, another component of a property biosecurity plan is regular surveillance to detect new incursions of pests, weeds and diseases. To detect new outbreaks of fireweed, conduct monitoring at sites of high risk for new weed incursions, and remove or otherwise kill any plants before they set seed.

John Virtue

An isolated fireweed in a farm shelter belt.

To detect fireweed, search the following higher risk areas on a fortnightly to monthly basis from autumn to spring (Sindel and Coleman 2012):

- parking areas and machinery washdown bays/ areas
- roads, tracks and other vehicle access areas
- in and around windbreaks
- property boundaries
- hillsides known to 'catch' windblown fireweed from surrounding areas
- livestock camps, feeding areas and other areas where trampling occurs
- around dams and other wet areas
- gateways and fence lines
- near sheds, tanks, stockyards and other structures
- where materials such as fodder, mulch, topsoil have been introduced
- where service vehicles and borrowed machinery have been into paddocks
- newly cultivated areas
- areas of earthworks.

Areas of bare or disturbed ground are more likely to have fireweed growing. Locations of treated or removed plants should be recorded and mapped, so that it is easy to return to the same location to search for further fireweed emergence.

Paul Carter

Farm tracks can provide bare, disturbed ground suitable for fireweed.

2.4 The importance of ground cover

Key point

- **Dense ground cover will suppress fireweed germination and growth.**

Establishing and maintaining dense, competitive ground cover is one of the best ways to limit the germination and establishment of fireweed. Fireweed germinates in response to bare and disturbed ground and reduced vegetative cover. Maintenance of competitive ground cover is particularly critical during the peak fireweed germination period in autumn.

Achieving good competition will depend on your situation and management purpose:

- For properties with livestock – aim to establish and maintain dense, vigorous pastures.
- For amenity areas – maintain dense lawns (e.g. raised mower height) and plant groundcover plants.
- On roadsides – maintain or establish competitive, low-growing native vegetation, or otherwise maintain grass swards.
- In areas of degraded and disturbed native vegetation that fireweed may invade – regenerate and restore with indigenous plantings of quick-growing ground covers, dense shrubs and shading trees.

Note that dense ground cover does not completely prevent fireweed establishing. For example, occasional plants can even emerge through dense kikuyu. However, the number of fireweed plants that need to be controlled by other means will be much lower.

John Virtue

A lack of competitive pasture species enables high fireweed density.

John Virtue

Thick native kangaroo grass on a roadside keeping fireweed at a low density.

John Virtue

A dense, well-maintained kikuyu pasture limits fireweed establishment.

2.5 Growing competitive and productive pastures

Key points

- **Grow locally adapted, competitive, perennial pasture species to suppress fireweed and other weeds.**
- **A mix of warm and cool season pasture grasses will provide productivity and cover throughout the year.**
- **Soil exposure or disturbance while establishing or renovating pastures can stimulate fireweed germination, which in turn needs controlling to avoid competition with pasture seedlings.**
- **Seek local, professional advice on pasture establishment and management tailored to your property.**

Vigorous, nutritious, sustainable pastures are the fundamental basis of productive, grass-fed livestock enterprises. Maintaining the density and growth of such pastures brings yield benefits for meat, milk and fibre production as well as sustained feed supply for companion animals (e.g. horses). It also provides competitiveness to suppress fireweed establishment and growth. The key is to ensure well-adapted, well-managed pasture species.

The key elements of growing and maintaining healthy pastures are:

- selecting pasture species and varieties suited to local climatic and soil conditions
- diversity of pasture species for growth in different seasons
- nutrition (including fertilisers, planting legumes and liming)
- rotational grazing
- weed and other pest control, especially at establishment.

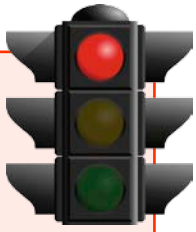
John Virtue

A thick winter sward of cocksfoot pasture.

It is acknowledged that dense pastures can be challenging to achieve. Constraints include:

- dryland pastures subject to seasonal drought
- less productive soils
- non-arable country
- hobby farms with low (or nil) economic returns per hectare
- high-stocking densities
- small properties lacking economies of scale
- lack of time, expertise or equipment.

Nevertheless, the focus should still be on the 'bigger picture' of achieving more productive pastures, rather than solely on controlling fireweed.



Note that some existing native pastures can have legal conservation protection – determine whether this applies to you before undertaking any activity that may harm them.

2.5.1 Pasture species competitive against fireweed

A dense pasture sward from early autumn into winter is important to reduce fireweed germination (Figure 2.1). This includes both actively growing pasture and dead plant material (leaf litter) covering the soil surface. Warm season (also known as 'tropical') perennial grasses, such as kikuyu, should not be grazed hard in late summer; this allows them to regrow and thicken up by autumn. Similarly, the density of cool season (also known as 'temperate') perennial grasses, such as phalaris (*Phalaris aquatica*), should be maintained to enable quick recovery of ground cover each autumn. From mid-autumn to early spring, actively growing, cool season pasture species are important for suppressing fireweed.

A diverse pasture mix of annual and perennial, warm and cool season grasses, legumes and other forbs provides greater resilience, more consistent growth during the whole year and variation in livestock diet. It also ensures greater competitiveness with fireweed. Figure 2.1 demonstrates that a 'feed gap' typically occurs in winter for warm season grasses and in late summer to early autumn for cool season grasses – hence the importance of having a mix of both.

Different grasses, legumes and other forbs are suited to different livestock enterprises, climates and soil types. Seek local advice from an agronomist or pastures officer for the best options and varieties for your property. Information sources to select and manage pasture species include state government departments of primary industry and various livestock industry websites (see Section 5.2). For example, NSW DPI provides information on an extensive list of species and varieties, available at www.dpi.nsw.gov.au/agriculture/pastures-and-rangelands/species-varieties.

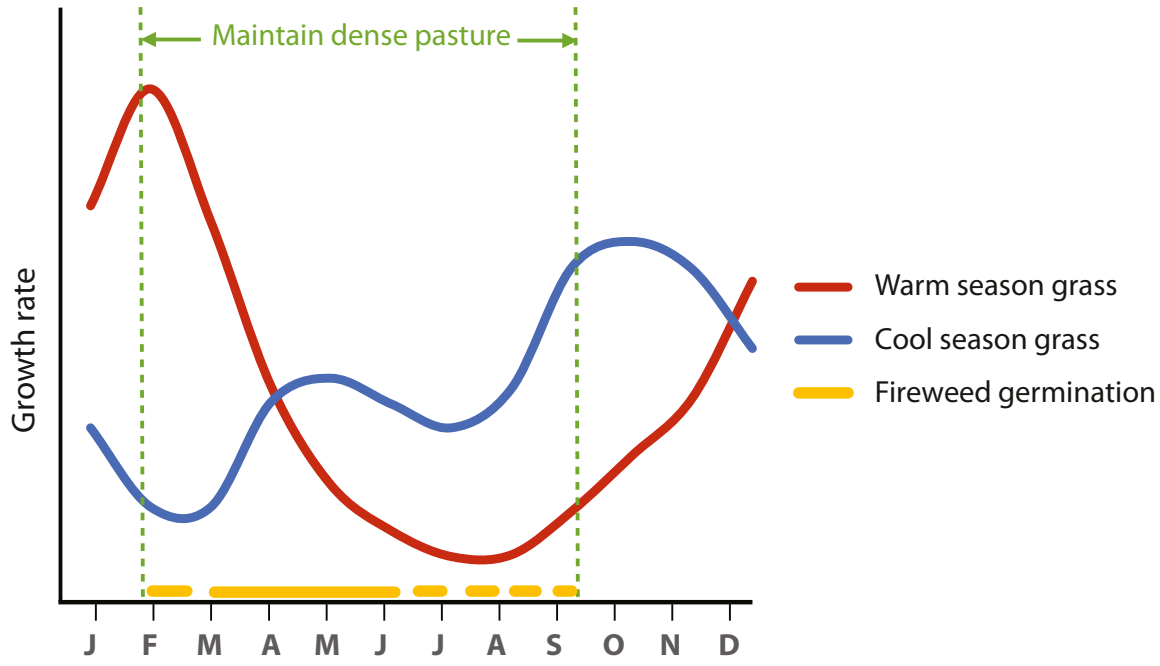


Figure 2.1 Growth pattern of warm season and cool season perennial grasses during the year, overlaid with timing of fireweed germination and seedling growth.

Pasture species reported to provide good suppression of fireweed are:

- cocksfoot (*Dactylis glomerata*)
- kikuyu (*Cenchrus clandestinus*)
- paspalum (*Paspalum dilatatum*)
- phalaris (*Phalaris aquatica*)
- Rhodes grass (*Chloris gayana*)
- ryegrasses (annual, biennial and perennial forms of *Lolium* spp.)
- setaria (*Setaria sphacelata*)
- tall fescue (*Festuca arundinacea*)
- weeping grass (*Microlaena stipoides*)
- white clover (*Trifolium repens*).

Further detail on these species is given in Section 5.3.

Among the warm season pasture grasses, kikuyu is particularly effective at suppressing fireweed because its active growth continues further into autumn than that of other warm season species such as paspalum (Sindel, 2009).

In pastures, low-growing species such as couch grass (*Cynodon dactylon*), carpet grass (*Axonopis fissifolius*) and buffalo grass (*Stenotaphrum secundatum*) provide less ground cover, giving poorer suppression of fireweed than that of taller grasses.

2.5.2 Establishing or renovating a perennial pasture

Key information sources for this section: Ayres et al. (2016), NSW DPI (2022a).

A new or renovated perennial pasture is an investment in future livestock productivity and carrying capacity, delivering increased financial returns over multiple years. However careful planning is required, including determining:

- the sequence and timing of steps required
- what inputs (e.g. pasture species and varieties, fertilisers, herbicides, liming) and equipment are needed
- costs and budgets
- alternative locations for livestock until the new pasture is ready for grazing
- how to manage the risk of stimulating fireweed germination during pasture establishment.

Establishing or renovating a pasture can be expensive. Seek professional advice and any necessary assistance to ensure successful pasture establishment. There are farm advisory and contractor businesses that can assist you.

Paddock selection

Choose which paddocks are best to be pasture-improved first. Paddocks with lower fireweed density and those where fireweed flowering has been prevented for several years should be prioritised. These would have a smaller fireweed soil seedbank and therefore less fireweed emergence to manage during pasture establishment.

Soil fertility needs

Test paddock soils (pH and nutrient status) to determine whether liming is required to reduce acidity and what fertiliser will be needed for strong pasture growth. Key nutrients that may be deficient include nitrogen (N), phosphorus (P), sulphur (S), potassium (K) and molybdenum (Mo). Pasture legumes will fix soil nitrogen but still require other nutrients to grow well, particularly P, S and Mo (Leech et al., 2009).

Stop weed seed set

Seed set of all weeds should be limited in the one to two years prior to pasture sowing to reduce competition with pasture seedlings. Techniques to do this include spray topping or pasture topping, spray grazing for broadleaf weeds (not suitable for toxic weeds such as fireweed), slashing, and spray or cultivated fallow. Each are described in more detail in NSW DPI's **Temperate perennial pasture establishment guide** available at http://www.dpi.nsw.gov.au/agriculture/pastures-and-rangelands/establishment-mgmt/establishment/temperate-perennial-pasture-establishment-guide (Ayres et al., 2016).

Pasture sowing techniques

There are three different ways to sow pasture seed.

Direct drilling involves making narrow slots or drills in the soil for sowing seed, leaving most of the soil surface intact. Existing pasture and weed biomass should be removed just prior to sowing by hard grazing (but not if fireweed is present and poses a poisoning risk), mulching to near ground level, broad-spectrum herbicides and/or burning.

Conventional sowing involves several soil cultivations (e.g. ploughing, harrowing) to prepare a fine seedbed to plant into. This stimulates weed germination, including fireweed. Herbicides or further cultivations are required to control weeds prior to sowing.

Broadcasting involves dropping pasture seed onto the soil surface from ground machinery or a plane after the surface cover has been removed by hard grazing and/or herbicide treatment. This is a higher risk approach in terms of successful pasture establishment because seeds are left more exposed.

Table 2.2 lists the pros and cons of these methods. From a fireweed perspective, minimal soil disturbance is preferred to avoid triggering germination.

Table 2.2 Comparison of three methods of sowing pasture seed.

Sowing method	Pros	Cons
Direct drilling / Minimum tillage	▪ Minimises soil disturbance – less fireweed seed brought to the soil surface and triggered to germinate ▪ Precise seed placement aids germination and seedling establishment ▪ Reduced soil erosion risk and damage to soil structure ▪ Conserves soil moisture	▪ Removal of existing pasture and weed biomass can expose the soil surface, stimulating fireweed germination
Conventional sowing	▪ Suitable for heavy clay or compacted soils ▪ Smooths out uneven soil surfaces ▪ Digs out weedy perennial grasses ▪ Can incorporate lime ▪ Precise seed placement aids germination and seedling establishment	▪ High soil disturbance can trigger mass fireweed germination ▪ Damage to soil structure ▪ Soil exposed to erosion
Broadcasting / Surface sowing	▪ No soil disturbance to trigger fireweed germination ▪ Suitable for large-seeded species such as ryegrass ▪ Enables sowing in non-arable and highly inaccessible areas	▪ Pasture seeds and seedlings are more vulnerable to desiccation, pests (including ant harvesting) and weed competition

Post-sowing weed control

Weed control continues to be important as new pasture seedlings are establishing. Many pasture species are slow growing as seedlings and are susceptible to weed competition. Herbicides can provide selective control of weeds, and local advice should be sought on what to use for the problem weeds present.

It is highly likely that fireweed will need to be controlled in newly establishing pastures (see Section 5.4 for selective herbicide options). Short-term, high-stocking rates of sheep can be used for fireweed control (see Section 2.6) in young pastures, but only after the species sown are at least 10 cm tall and well-anchored in the soil to withstand grazing. Ideally, new perennial pastures should not be grazed in the first year of establishment so that they thicken up and set seed.

2.5.3 Oversowing into existing pasture

Key information sources for this section: Dairy Australia (2019), Dart and Fulkerson (2014), Leech et al. (2009).

Adding greater species diversity to an existing perennial grass base can increase pasture competitiveness, productivity and sustainability. This includes ensuring a legume component in pastures to build soil nitrogen levels.

For example, kikuyu is a common and persistent pasture species in coastal and other seasonally warm, high rainfall areas of eastern Australia. However, its growth slows from late autumn to early spring due to low temperatures, which coincides with the period of fireweed germination and growth. Cool season species such as ryegrass, oats and/or clovers can be sown into the kikuyu pasture in autumn to address the winter feed gap and compete with fireweed.

When oversowing, conflicts arise between, on the one hand, opening-up the existing pasture for the newly sown seeds to germinate and grow quickly, and on the other, stimulating fireweed to germinate.

John Virtue

Fireweed seedlings emerging after sod seeding to renovate a pasture.

Oversowing can be done by direct drilling into the pasture (i.e. 'sod seeding') using narrow seeding rows to minimise soil disturbance. Alternatively, oversowing can be done by broadcasting seed. Mulching the existing pasture following broadcasting provides a thin covering of the seed and soil surface. Such 'mulch planting' is suitable for larger seeded species like ryegrass and clovers.

General requirements for oversowing

- Reduce existing pasture to close to ground level, so that newly germinating pasture seedlings can access light. This may be achieved through:
  - heavy grazing – but not if there is a fireweed poisoning risk
  - cutting (i.e. mulch, mow or slash)
  - non-selective herbicide, or
  - a combination of these.
- Direct drilling (i.e. sod seeding into the existing pasture) is best for small seeded species with less vigorous seedlings, such as phalaris, cocksfoot, fescue and lucerne (*Medicago sativa*).
- Broadcasting seed onto the soil surface is an option for larger seeded species.
- Apply fertiliser to encourage rapid growth of the pasture.
- Control seedling fireweed (and other weeds), where required, with selective herbicide.
- Allow the new pasture to establish before reintroducing livestock.

2.5.4 Established pasture management

Weed control, fertilising and strategic grazing (see Section 2.6) are important ongoing actions to build and maintain the proportion of desirable pasture species in grazing paddocks (Leech et al., 2009). Regularly conduct a paddock health check.

- What pasture species and weeds are present?
- What does a soil test say about fertility and acidity?
- Is grazing uneven and are some areas prone to overgrazing?

This assessment will inform how and where to invest to improve pasture performance. Local professional advice should be sought before making a final decision on how to proceed.

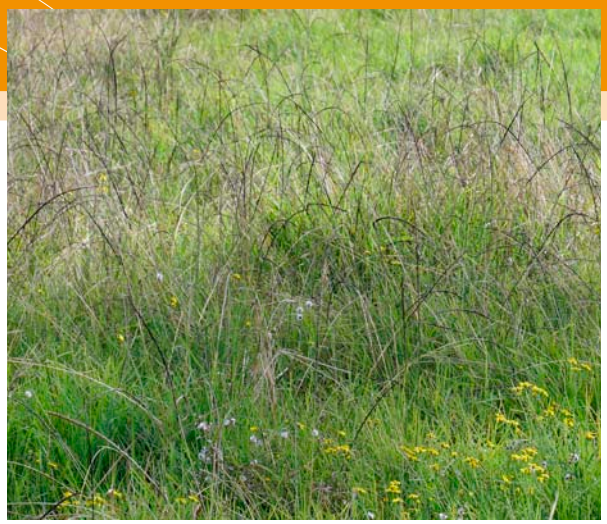
Weed control

Herbicides can be used to manipulate the balance between pasture weeds and desirable pasture species. Selective herbicides can be used to target particular types of weeds while limiting impacts on pasture species (e.g. a broadleaf herbicide sprayed over a grass pasture). Spot spraying of target weeds can be done if a herbicide may damage pasture species. Some weeds can also be selectively controlled using a wick wiper if the desirable pasture species is shorter or has been grazed down.

Non-palatable, perennial tussock grasses, such as giant Parramatta grass (*Sporobolus fertilis*) and African lovegrass (*Eragrostis curvula*), are also problematic in many fireweed-affected areas and should not be overlooked in the quest to control fireweed.

Soil fertility needs

As with pasture establishment, monitoring soil fertility and pH is important to maintain pasture productivity. Matching the timing of fertiliser application to the start of periods of active pasture growth is crucial, such as spring application for warm season grasses and winter top-dressing with nitrogen for ryegrass pastures.



John Virtue

African lovegrass and fireweed in a kikuyu pasture.

Fireweed can also grow rapidly in response to fertilisers, particularly superphosphate. Desirable pasture species need to be present at sufficient density to be able to quickly respond to the additional nutrients. Plans should be made for selective control of fireweed following fertiliser application in case it has stimulated a flush of germination and growth (Allan et al., 2005).

Soil pH has significant effects on pasture plant performance. It can affect the availability of soil nutrients and the health of beneficial microorganisms. Liming should be considered for acidic soils with a pH (Ca) of less than 5.0.

2.5.5 Further information and training on pasture management

Section 5.2 lists sources of further information, online decision tools and training on establishing and growing pastures. Providers of information include state government primary industries departments, regional natural resource management bodies (e.g. NSW Local Land Services), commercial agronomy and farm advisory and training services, rural supplies stores, pasture seed suppliers and livestock organisations (e.g. Meat and Livestock Australia, Dairy Australia, Future Beef).

It can also be beneficial to talk with neighbours about their local experiences in establishing pastures and to attend farmer meetings, field days and paddock walks.

2.6 Strategic grazing

Key information sources for this section: Graham (2017), Ayres et al. (2016), O'Sullivan et al. (2013).

Key points

- **Overgrazing favours fireweed and increases risk of poisoning.**
- **Determine a sustainable stocking rate to avoid overgrazing.**
- **Practise rotational grazing to optimise pasture growth and competitiveness.**
- **Horse pastures are highly prone to selective grazing and need regular rest for pasture recovery.**

Grazing pressure is a major driver of pasture productivity, competitiveness and composition. An appropriate grazing strategy is required that optimises the use of pasture throughout the year, maintains ground cover and gives desirable plants time to recover and regrow after periods of grazing. Stocking rate is critical.

Long-term overstocking risks bare paddocks prone to soil erosion, death of valuable pasture species and proliferation of weedy, non-palatable species – including dense fireweed, which increases the risk of cattle or horse poisoning.

Stocking rate

'Stocking rate' is the current number of grazing animals per unit area of land; it is a measure of livestock density often determined as 'head per hectare'. 'Carrying capacity' is the stocking rate that a paddock or whole property can sustainably have, considering various factors such as pasture type and productivity, climate, soil fertility and livestock type. Carrying capacity is not a fixed number and will vary throughout the year (e.g. caused by slow pasture growth due to winter cold or to summer dry conditions). Carrying capacity will also decline with periods of extended drought or waterlogging.

John Virtue

Match stocking density to fodder availability to avoid overgrazing.

Pasture availability should be regularly monitored to detect any long-term changes in carrying capacity and to determine when livestock should be moved to another paddock. Feed gaps throughout the year can be addressed through conserving fodder (e.g. making hay or silage) for later supplementary feeding, where economical to do so.

Rotational grazing

Grazing pressure is the combination of stocking rate and how long and often stock are kept in a paddock. Rotational grazing is a way to regulate grazing pressure and is important both for pasture productivity and fireweed management. Frequently rotating stock between paddocks, with periods of pasture recovery in between, can enable higher stocking rates. The pasture species are grazed down so that they are encouraged to stay in a vegetative stage of growth rather than going to seed. The pasture is then given a rest period to recover leaf area and photosynthesise, rebuilding reserves for new growth.

John Virtue

Rotate between paddocks to allow pastures to recover.

Warm season (tropical) perennial grasses are most productive when kept at a green, leafy stage of growth by rotationally grazing smaller paddocks at high stock densities (Lodge, 2010). Perennial pasture grasses also need a rest period every few years, of at least six weeks during their flowering season, to allow for seed set and to replenish root reserves.

There are many ways to practise rotational grazing. These vary in the length, frequency and intensity of pasture rotation and in the length of the rest period. The number and size of paddocks, pasture growth rate at various times of year and livestock herd sizes are all factors in designing the optimal grazing system for a property.

For example, a system could be one week's grazing and six week's rest for a paddock, although it is better to base stock movements on monitoring of seasonal pasture growth in individual paddocks rather than on fixed timing. This simple example of one week on, six weeks off requires seven paddocks of similar size through which to rotate.

Paddocks should ideally be fenced according to land type, so that pasture growth is even throughout and no areas are frequently subject to over or under grazing.

Pasture mulching

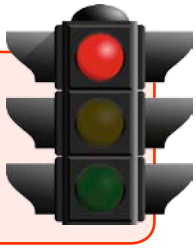
Pasture mulching is a mechanical technique commonly used to reinvigorate pastures. Pasture is cut to a short height and finely chopped to be spread as a surface mulch. Removal of tall, rank pastures encourages new pasture growth and reshooting from near ground level. It also cuts down ungrazed, weedy species so they do not have a competitive advantage as the pasture recovers.

Mulching after a period of grazing is common practice in dairy farms with kikuyu pastures. Mulching can also be used to reinvigorate pastures hit by frosts. However, the potential for fireweed regrowth (or germination) needs to be considered, including the need for any herbicide treatment.

Rowley Beckett

Rotational grazing provides the opportunity to monitor and treat paddocks for fireweed between grazing periods. The herbicide bromoxynil is highly effective to control young fireweed, but any herbicide products containing this active ingredient have an eight-week withholding period after spraying until stock can again graze the pasture.

Use various pasture management information sources and seek local, professional advice to determine your property's carrying capacity and optimal rotational grazing system.



Types of grazing systems

Further information: Graham (2017), Ayres et al. (2016) and O'Sullivan et al. (2013).

Rotational grazing

Pastures have a period of grazing followed by a period of rest. This may be on a fixed-timing basis or vary according to seasonal pasture growth rates and differences in paddock size and productivity.

Cell or strip grazing

Electric or other temporary fencing is used to split paddocks into small areas for high intensity grazing of 2–3 days (or even less depending on herd size), followed by a long recovery period for regrowth. Stock access to drinking water needs to be considered. This system is commonly used in dairy farming.

Set stocking

A low-input form of long rotation grazing. A paddock may be grazed for an extended period (e.g. three months) when there is a high level of feed available, and then rested or kept at a much lower stocking rate at other times. From a fireweed perspective, spring grazing is preferred, allowing recovery of the pasture sward over summer to then inhibit the weed's germination in autumn.

Tactical grazing

A strategic, flexible grazing system based on setting specific objectives and determining strategies to achieve these. Tactics may vary year to year, according to monitoring of pasture growth and composition and livestock productivity. This is the optimal approach promoted in PROGRAZE™ (Graham, 2017).

Continuous stocking

A paddock constantly has stock year-round. This grazing system is the most sensitive to correct stocking rate. It is the least preferred grazing system because there are high risks of overstocking leading to:

- overgrazing and death of palatable, productive pasture species
- selecting for low palatability fodder or non-palatable weeds (e.g. fireweed)
- selecting for low-growing pasture species lacking competitiveness and surface cover to suppress fireweed
- exposing bare soil to erosion and loss of organic matter.

Understocking risks are also associated with continual grazing. Having too few stock means there is no competition for fodder; consequently, only highly palatable species are eaten and hence overgrazed. The lower palatability species and weeds can then gain a competitive advantage and become dominant.

2.6.1 Horse paddocks and fireweed

Key information sources for this section: Allan et al. (2007), SEQ Catchments (2018).

Brian Sindel

Horse paddocks are highly prone to fireweed invasion.

Pastures are challenging to manage in horse paddocks. Horses are highly selective grazers and like to graze close to the ground. This puts intense grazing pressure on palatable pasture grasses, especially in small paddocks. Unmanaged horse paddocks tend to become dominated by non-palatable weeds and bare areas of ground. This is ideal for fireweed, which is highly toxic to horses.

As with other grazing livestock, maintaining pasture cover in horse paddocks is important to suppress weeds and prevent soil erosion. Access to nutritious pasture also reduces the need for additional purchased feed.

Pasture species for horses

Ryegrass, fescue, cocksfoot and Rhodes grass are pasture species suitable for horses that also offer competitiveness with fireweed. In choosing perennial ryegrass and fescue varieties, consideration should also be given to endophyte status (i.e. fungi strains that grow within the plant, some of which can pose toxicity problems).

Kikuyu is a common coastal horse pasture, but it also poses the risk of oxalate poisoning. This risk is typically reduced by providing a calcium supplement. Setaria and a range of other tropical pasture grasses should be avoided owing to their high levels of oxalates.

Carrying capacity

Allan et al. (2007) suggest a carrying capacity of one horse per 2 ha where there is poor pasture, low soil fertility and mainly summer-dominant pasture. For a horse farm with improved, fertilised and irrigated pasture of summer and winter pasture species, a carrying capacity of four horses per 2 ha is suggested.

Rotational grazing

Paddock rotation is critical with horses to maintain or re-establish pastures. It is desirable to have at least three paddocks to rotate among. Horses should be grouped in one paddock at a time while the other paddocks are spelled.

Large paddocks can be split into smaller paddocks to enable pasture rotation. Where this is not possible because of small property size, alternatives are to stable or yard horses during pasture recovery periods, or to section off parts of a paddock using electric tape.

Horses should be removed from a paddock when the pasture is grazed down to around 5 cm high. Slash or mulch the paddock and apply fertiliser if soil fertility is low. Spread out manure across the pasture to distribute its nutrients. Paddocks should have an average pasture height of around 10–20 cm, depending on the pasture species, before horses are reintroduced.

Control weeds

Hand pull fireweed at any time, or spray with a selective herbicide during the pasture recovery phase. In addition to fireweed, other weeds poisonous to horses include annual ragweed (*Ambrosia artemisiifolia*), Crofton weed (*Ageratina adenophora*), mother of millions (*Bryophyllum* spp.)

and Paterson's curse (*Echium plantagineum*). Be on the lookout for new weeds introduced in feed and spread in horse manure.

Seek local, professional advice on the best ways to maintain and improve horse pastures for your situation.

2.7 Sheep and goat grazing of fireweed

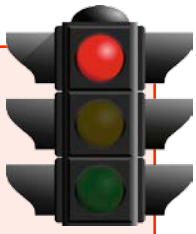
Key points

- **Sheep and goats will eat fireweed and can substantially reduce its density.**
- **While relatively tolerant of fireweed's pyrrolizidine alkaloids toxins, caution is still advised if grazing dense infestations.**
- **Sheep and goats have specific management requirements, including health, fencing and shearing (for some breeds).**

Sheep and goats readily eat fireweed and have a higher tolerance of the pyrrolizidine alkaloid (PA) toxins in fireweed than do cattle and horses (NSW DPI, 2012). They are being successfully used to keep fireweed at low levels in pastures on both farming and lifestyle properties (see case studies 4.2, 4.3, 4.6). Typically, fireweed flowers are eaten first and the rest of the plants are grazed later. A range of sheep and goat breeds are being used, often integrated with other livestock.

It should be noted that sheep and goats are not immune from fireweed poisoning, and their level of intake of the weed still needs to be managed. Sheep and goats' ability to detoxify PAs is thought to be through microbial breakdown during digestion in the rumen and through specific liver enzymes (Giaretta et al., 2014; Johnston, 2007; Panziera et al., 2018). They are estimated to be 10–20 times less susceptible to PA poisoning than are cattle and horses (Hooper, 1978).

However, a diet very high in PA intake may cause sudden or long-term chronic poisoning in sheep or goats. In addition to the typical symptoms of PA poisoning in animals (see Section 1.4.1), internal build-up of copper to toxic levels can also occur (Ilha et al., 2001; Seaman, 1987). Incidents of PA poisoning in sheep have been described in Brazil (Giaretta et al., 2014; Grecco et al., 2011; Ilha et al., 2001; Karam et al., 2011), where sheep were grazing pastures heavily invaded by *Senecio* spp. and where there was little alternative feed available. One incident of sheep poisoning by fireweed in Australia was documented in Seaman (1987). However, there are no documented records since of fireweed clinically affecting sheep or goats in NSW (Schaefer, 2023).



Take care in exposing sheep or goats to high levels of fireweed, whether in a short period with limited other feed available or over a prolonged period in pastures with a high content of fireweed. Sheep or goats should always have plentiful access to pasture grasses and forbs as alternative sources of feed. Manage nutrition to avoid high levels of copper in the diet.

John Virtue

Wiltshire sheep providing fireweed control at Bega.

Lessons from overseas – research on sheep and goat suppression of fireweed

Research from Brazil has shown that fireweed density rapidly declines and remains at negligible levels under continuous sheep grazing (Bandarra et al., 2012; Stigger et al., 2018). Liver biopsies undertaken for the Brazilian research did not detect any damage in sheep during the experiments, which ranged from grazing periods of 90 days to two years in length (Bandarra et al., 2012; Stigger et al., 2018). However, it should be noted that sheep were grazing in mixed pastures containing grasses and legumes in addition to fireweed and *S. brasiliensis* (another *Senecio* weed containing toxic PAs).

While sheep and goats do not eradicate fireweed, a Hawaiian study found that removing feral goats led to an increase in fireweed from <0.01% to 14.7% ground cover (Kellner et al., 2011). Research in Brazil similarly observed that fireweed starts to return once sheep are removed. Hence, they should be considered part of a long-term grazing system for ongoing fireweed suppression.

In Brazil, recommended stocking rates of sheep for controlling fireweed are three to four adults per ha (Bandarra et al., 2012; Stigger et al., 2018). Sheep or goats can be integrated with a cattle enterprise, either co-grazing or 'cleaning up' paddocks prior to introducing cattle.

2.7.1 Management requirements of sheep and goats

Sheep and goats have specific management requirements and can be much more labour and time demanding than cattle. The following should be considered before deciding to introduce them to your property.

Health and welfare

- **Control internal parasites** – These include roundworms, tapeworms and flukes, all of which can cause severe health issues. Barber's pole worm (*Haemonchus contortus*) is a major problem in coastal pastures. These roundworms cause anaemia and can be fatal in sheep and goats. Control advice is given at www.wormboss.com.au.
- **Prevent flystrike** – This is favoured by extended periods of warm season rains. It is more prevalent in highly wrinkled Merino sheep, but other breeds can also be susceptible in certain circumstances. Management information is available at www.flyboss.com.au/sheep-goats/.
- **Control wild dogs** – Sheep and goats are highly prone to wild dog attack, causing severe injury and death. Participating in district wild dog control programs, having companion animals (e.g. donkeys) and/or securely yarding small flocks at night can reduce this risk. However, in some areas the wild dog burden may mean it is not possible to safely run sheep or goats.

Infrastructure and marketing

- **Fencing** – This includes boundary and internal ringlock fencing and livestock holding yards. Goats, and some sheep breeds such as Dorpers, can be more challenging to contain.
- **Shearing and/or crutching** – Managing certain sheep and goat breeds will require facilities to do shearing. Modifying existing infrastructure may provide innovative and low-cost options. Self-shedding breeds of meat sheep, such as Dorper and Wiltshire, do not need shearing.
- **Access to markets** – How to sell animals and their products profitably? Factors include transport costs to market and the amount of produce to be traded. Consider collaborating with neighbours and developing local business models (Johnston 2007).

2.8 Herbicide control

Key points

- **A range of herbicides are available for use on fireweed.**
- **These differ in their recommended timing, off-target risks, withholding periods and methods of application.**
- **It is a legal requirement to follow the instructions on a herbicide label.**
- **Fireweed seedlings are more susceptible to herbicides than are adult plants.**
- **Fireweed should be sprayed before flowering.**

Herbicides are a fundamental tool in the control of fireweed. They are most effective when used in combination with other control measures. A range of herbicides are registered for use on fireweed. Each has strengths and weaknesses, including recommended timing, withholding periods for livestock and risks of off-target damage to desirable plants.

Types of herbicides that can be used on fireweed are discussed below, and current registrations and permitted uses are detailed in Section 5.4. There can be many commercial products for a particular type of herbicide and concentration. Their availability may change over time and new products also come onto the market. Check with your agronomist or chemical reseller. Registered products and uses can be searched at the Australian Pesticides and Veterinary Medicines Authority (APVMA) PubCRIS database website, portal.apvma.gov.au/pubcris.

Only herbicides legally approved by the APVMA may be used. These are available either as **registrations**, where instructions for control of fireweed is specifically mentioned on a herbicide product's label, or where a **minor use permit** has been obtained from the APVMA for a particular purpose. In both cases, the herbicide may only be used in the specified situation. State and territory laws may enable use of other herbicides on a weed, but at the user's risk (see Section 5.4).

Minor use permits enable specified uses of herbicides that are not otherwise registered (and presented on product labels) for a particular weed. A number of state-based permits cover fireweed, as listed in Table 5.8. Note that permits have expiry dates, and these should be checked to ensure such use is still permitted. Permits and their current status can be accessed on the APVMA website.

To choose the most appropriate herbicide for your situation, you will need to check which herbicides are registered or permitted for use on fireweed in your state or territory. Most state and territory jurisdictions provide specific herbicide advice for declared weeds on their websites. For fireweed, the NSW and Qld governments' biosecurity websites (see Section 5.5) provide current advice on herbicides for use in their state.

2.8.1 Safe use of herbicides

All herbicides come with a label that is a legal document. The user is required to read and follow all instructions when preparing and applying the herbicide.

A herbicide label details the personal protective equipment (PPE) required, the mix rate and the appropriate growth stage for application, and how to use the herbicide safely and effectively. Each herbicide also has a Safety Data Sheet.

Operator safety

For safety, herbicide users should wear:

- chemical resistant gloves
- eye protection
- respirator (with a filter appropriate to the level of herbicide toxicity)
- clothes, hat and boots that cover the whole body.

Peter Casey

PPE may include gloves, eye protection, mask and covered clothes and shoes.

For higher safety risk herbicides, more PPE and additional precautions may apply, including wearing a full face respirator and chemical-resistant overalls. Follow label requirements and consult the Safety Data Sheet on the health risks of exposure.

Environmental protection

In addition to personal safety, herbicide labels also have mandatory requirements to protect the environment and non-target plants during their use. As a chemical user, you have a legal obligation to avoid spray drift damage and to ensure that the chemicals you apply stay within the target area.

Prevent herbicide drift during application to protect crops, native vegetation and other plants, and to avoid 'chemical trespass' onto neighbouring properties. Measures to reduce the risk of spray drift include spraying when the wind is 3–20 km per hour or when there are no surface temperature inversion conditions, using a coarse spray quality nozzle type, and having buffer zones. Mandatory spray drift instructions may be given on herbicide labels.

Avoid use near streams, rivers and waterways, unless a herbicide is specifically registered for use in aquatic situations. Follow label directions regarding any risk of soil-applied herbicides spreading via runoff following rainfall or irrigation.

Many weeds across Australia have developed resistance to particular types of herbicides – rendering them much more difficult to control.

Herbicides are classified into 'groups' based on mode of action, which relates to the herbicide's chemistry type and its mechanism for causing plant death. In Australia, indication of these groups is shifting from letters to numbers to align with international herbicide classification (CropLife Australia, 2022).

Frequent use of herbicides with the same mode of action risks selecting for individual plants with genetic changes that render them resistant to the herbicide's effects. These plants and their progeny survive subsequent treatments of such herbicides, building up in numbers over time.

Herbicide resistance has not yet been detected in fireweed in Australia, but two other *Senecio* species have cases of herbicide resistance overseas (WeedScience.org, 2022).

To avoid herbicide resistance, it is important to rotate the use of different groups of herbicides. Using mixtures of herbicides with different modes of action also reduces the risk, although there are limited registered choices for such mixtures for fireweed (see Section 5.4). Do not mix herbicides unless approval to do so is given on the label. Any case of suspected herbicide resistance should be promptly reported to local weed management authorities.

Withholding periods

Certain herbicides have withholding periods during which livestock must be excluded from grazing treated areas and cutting of pastures for hay or silage should be avoided. This minimises the risk of herbicide residues in livestock products sold to market. Some herbicides also provide separate, specific label instructions on managing the risk of herbicide residues in other farm products such as manures and composts.

2.8.2 Effective use of herbicides

Successful herbicidal control depends on selecting the correct herbicide for the target species and growth stage, the weather conditions during and after spraying, how thoroughly the herbicide is applied, and the herbicide mix and application rate.

For spraying, wind speeds should be low (<15 kph), and no rain should be expected in the following six hours.

Do not apply herbicide to plants under stress because herbicide will not be absorbed and translocated effectively, resulting in a reduced level of control. Plants may be stressed because of:

- dry soil
- low humidity
- air temperatures above 30°C
- frost.

Take steps to maximise effectiveness of herbicides

- Mix dye with the herbicide to help minimise missed areas and prevent over spraying (double spraying). Similarly, a foam marker can be used to indicate the edges of boom spraying.
- Use an adjuvant to improve herbicide uptake. Always read the adjuvant's labels to ensure it is compatible with a particular herbicide and check any restrictions on its use (e.g. avoiding use near waterways).
- Ensure spray equipment is correctly calibrated and maintained.

Calibrate your spraying

Herbicide spraying can be performed by boom, knapsack or handgun. A herbicide's label lists which method can be used. Herbicide control techniques are described at: www.dpi.nsw.gov.au/biosecurity/weeds/weed-control/herbicides/control-techniques-using-herbicides

The particular spray equipment you use must be calibrated so that the correct herbicide rate is applied. This refers to both the amount of herbicide active ingredient applied per hectare and the water volume to be applied per hectare (where this is specified on the label).

The NSW DPI provides instructions on how to calibrate spray equipment: www.dpi.nsw.gov.au/biosecurity/weeds/weed-control/herbicides/spray-equipment-calibration-methods

2.8.3 Herbicides for fireweed

A range of herbicides and herbicide mixes are registered or allowed under APVMA permit for fireweed control in pastures. The main types of herbicides are summarised in Table 2.3, and further detail is provided in Table 5.8.

Other types of herbicides are registered for use on fireweed in cropping or non-agricultural situations (see Table 5.8). There are also herbicides registered for annual weeds generally, or annual broadleaf weeds (e.g. glyphosate may be used for spot spraying in certain circumstances).

'Organic' herbicides that are registered for control of annual weed seedlings include pine oil and acetic acid products. These may be effective against small fireweed plants. Complete spray coverage is required, and older plants may still regrow from the base.

Table 2.3 Herbicides registered or permitted for use on fireweed in pastures (see further information in Table 5.8).

Herbicides containing[a]:	Timing	Withholding period	Pasture legume damage risk	Limits on use	Other considerations
Bromoxynil **Group 6**	Most effective prior to flowering	8 weeks	Some – consult label for species at risk and temperature constraints	Check whether product is registered for use in your state or territory	Less effective on mature fireweed – risk of regrowth
Diflufenican **Group 12**	Seedlings up to 4-leaf stage	1 week or 8 weeks[b]	Some – consult label for species at risk and temperature constraints	Check whether product is registered for use in your state or territory	
2,4-D or MCPA **Group 4**	Young, actively growing plants	1 week	Some – consult label and seek local professional advice	2,4-D Qld only[c]	Spray drift risk Many crops, ornamentals and native plants are highly susceptible
Metsulfuron-methyl **Group 2**	Autumn	Nil	Yes – consult label and seek local professional advice	NSW and Qld under permits	Can impede growth of some grasses Soil persistence
Aminopyralid, halauxifen, fluroxypyr, picloram, triclopyr, aminocyclopyrachlor **Group 4**	Seedling and flowering plants	Consult label for residue advice	Yes – consult label and seek local professional advice	Check whether product is registered for use in your state or territory	Many crops, legumes, ornamentals and native plants are highly susceptible Soil persistence

[a] Herbicides that contain these active ingredients, including mixtures with other herbicides. The group number refers to the mode of action.

[b] One week for products that also contain MCPA, eight weeks for products that also contain bromoxynil.

[c] 2,4-D only registered for use of fireweed in Qld (as of May 2023). NSW has a permit for bromoxynil + 2,4-D amine.

2.8.4 When to spray fireweed

It is recommended to spray young fireweed plants in autumn, following rainfall events that trigger flushes of germination. This limits plant numbers for the year, their potential to dominate winter–spring pastures, and annual seed set. Learning to recognise fireweed seedlings for spraying is important (see Section 1.1.3). 'Rules of thumb' for timing are:

- waiting two to three weeks after the first significant rainfall event in autumn (Johnston, 2007)
- spraying when fireweed plants are small, with up to 8–10 leaves (Southern Rivers CMA, 2009)
- spraying before no more than 10% of plants have started to flower (Southern Rivers CMA, 2009).

Notwithstanding these rules, it may be best to wait for a second flush of germination in autumn to capitalise on a herbicide treatment (Sindel and Coleman, 2012). Spraying before flowering commences is vital – besides preventing seed set, large flowering plants can also be more difficult to kill.

Since fireweed can germinate in flushes from autumn to spring, a single annual herbicide application will likely not control all plants that year. Hence, herbicide use should be integrated with other control measures, particularly fostering competing vegetation (e.g. vigorous pastures) and managing grazing pressure. Spring spot spraying of individual plants can also be performed to 'mop up' areas of high fireweed density.

Figure 2.2 provides a calendar of herbicide use timing, based on the typical flush of autumn fireweed germination. Note that timing should be adjusted when flushes occur at other times of year.

<table>
<tr><th>Month</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Growth stage</td><td>Dead</td><td colspan="4">Increasing germination</td><td colspan="3">Establishment and early growth</td><td colspan="2">Flowering and senescence</td><td colspan="2">Death</td></tr>
<tr><td rowspan="3">Action</td><td colspan="2" rowspan="3">AVOID herbicide use</td><td colspan="3" rowspan="3">Spray seedlings. Best time for application is two to three weeks after first main rainfall and before 10% of the seedlings open their flowers</td><td colspan="3" rowspan="3">Spraying may be effective, but may require higher rates which has the potential to cause damage to non-target species</td><td colspan="4">Spot spraying with herbicides registered for this use may be effective</td></tr>
<tr><td colspan="4">AVOID broadacre spraying</td></tr>
<tr><td colspan="4">Plan management strategies for next year</td></tr>
</table>

Figure 2.2 Calendar of herbicide timing for control of fireweed. From Hunter Regional Weeds Committee (2019), after Johnston (2007) and Southern Rivers CMA (2009).

Budgeting for herbicide use should consider the following:

- cost of herbicide, at required application rate per ha
- total area to be treated and density of fireweed
- application equipment required, including fuel costs
- time and/or labour costs
- profitability of enterprise (expected return on investing in control of fireweed)
- alternative fodder needed during a grazing withholding period.

2.9 Physical control methods

Key points

- **Timing and frequency is critical if attempting to control fireweed by cutting pastures or lawns.**
- **Hand removal is labour intensive and requires ongoing commitment. It is best suited to small, isolated infestations.**
- **Soil cultivation stimulates fireweed germination.**
- **Mulches may assist fireweed suppression in amenity areas but need to be maintained.**

While a combination of competitive groundcover, grazing management and herbicides is at the core of optimising integrated management of fireweed, other control methods can further assist control. It is also recognised that some landholders prefer not to use herbicides.

2.9.1 Cutting

Cutting of fireweed by slashing, mowing or mulching is not an effective control measure unless it is done frequently *and* pasture or turf grasses are present that regrow faster to outcompete it. Fireweed can resprout when cut, even if cut close to ground level. The livestock poisoning risk of cut fireweed material also needs to be managed.

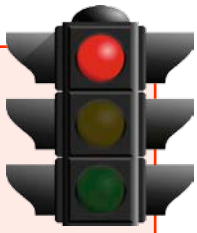
Frequent cutting is needed to weaken fireweed plants over time. Two cuts over a two-month period were found to reduce fireweed plant survival by up to 70% (Sindel et al., 1998). Repeated cutting at less than six-week intervals reduces fireweed growth and seeding (AWC, 2012).

Timing is important. Cutting in autumn and winter risks fireweed regrowth having a competitive advantage, unless the pasture is dense with actively regrowing, cool season grasses. Cutting from mid-spring onwards is more suitable for competitive regrowth of warm season grasses (e.g. kikuyu).

Delaying cutting of fireweed plants until they are large can be problematic. Fireweed will likely be in flower and setting seed at this time, hence there is a risk of spreading seed across a paddock. The regrowing fireweed can also become woody. This makes it more difficult to kill with herbicides and increases the risk that it will over-summer and regrow rapidly the following autumn.

John Virtue

Grass cutting needs to be frequent to suppress fireweed.



Cut fireweed material remains toxic to livestock, which find it hard to avoid when grazing mixed clippings. Pastures cannot be grazed again until they have regrown above the cut fireweed material and it has decomposed. To prevent poisoning, stock should be excluded for at least two weeks (Allan et al., 2005), longer in cooler times of the year.

2.9.2 Hand removal

Hand pulling of fireweed plants prior to flowering is commonly undertaken by land holders as a low-cost control measure for new, small or isolated infestations. It is most effective for scattered infestations that are less than 1 ha (Sindel et al., 2012). Hand removal is also good for areas at high

risk of seed dispersal, such as around cattle yards or sheds, and as a follow-up of occasional plants missed by herbicide treatment.

Depending on fireweed density and area, it can be time-consuming and labour intensive to detect, remove, bag and dispose of plants. It can also be hard to detect plants prior to flowering, risking seed being set before being found.

The basic method of hand pulling is to grab individual fireweed plants at the base of the stem and gently extract so that the whole plant, including the upper roots, is removed. This is easiest to do in wet soil after rainfall. Fireweed will not regrow from fine roots, so these do not need to be dug out.

John Virtue

John Virtue

Hand pulling and bagging of a fireweed plant, including roots.

Work health safety is important

To minimise risk of injury or exposure to plant chemicals:

- wear sturdy, impervious, comfortable gloves
- bend at the knees or work on your knees (with knee guards)
- be careful of footing in pugged or stony paddocks
- avoid repetitive strain – take rests and do not work in awkward positions
- work to your ability
- work in teams.

Plants should be placed into a sturdy bag (e.g. a used fertiliser bag) for disposal. This is particularly important for plants coming into flower or already seeding (being careful not to dislodge any seeds so that they are captured in the bag). Removing plants from paddocks also prevents livestock eating them.

Hand pulling is an ongoing, labour intensive commitment, best suited to very small properties or where fireweed is not widely established. In initial years, many long days might be required to remove high densities of plants. Long-lived seed in the soil and seed blowing in from surrounding properties means searching on a fortnightly basis to catch plants before they set seed. Often, certain parts of the property are 'hot spots', which require more frequent searching.

Disposal

Fireweed can be allowed to rot down in a bag or container and buried on the property or offsite at a council waste facility. While fireweed readily breaks down in compost, the effect on fireweed seed viability is not known. If composting at home, then the hot composting technique (Raabe, n.d.) is reputed to kill weed seeds because of the high temperatures generated, and hence is likely to be safer than traditional, fixed-heap composting. Fireweed should not be added to green waste for use in council or commercial composting.

2.9.3 Soil cultivation

Soil cultivation is the use of machinery (on a paddock scale) or hand tools (on a garden scale) to prepare planting beds for sowing crops or pastures, to control weeds and to incorporate organic materials such as crop stubbles into the soil.

The disturbance caused by soil cultivation can stimulate a flush of fireweed germination. Subsequent cultivations may be used to kill fireweed seedlings, but frequent cultivation can damage soil structure and risks erosion. The 'false seedbed' technique of very shallow 'tickle' cultivation can encourage surface weed seeds to germinate while having less effect on soil health than deep cultivation.

Cultivation is a control option for fireweed in cropping systems and home gardens, but it has limited use in other situations, such as pasture paddocks.

2.9.4 Mulches

Mulches are a physical barrier covering the soil surface. They can reduce germination, growth and spread of weeds. Mulches can be thin, impenetrable barriers to weed growth, such as black plastic used in strawberry production or biodegradable woven weed matting used to stabilise embankments. Alternatively, they can be thick, permeable layers of loose material, such as composted woodchips, straw or gravel.

Brian Sindel

Mass fireweed emergence stimulated by soil cultivation.

Mulching tips

- Use another weed control method before mulching, such as herbicide application or manual removal.
- Ensure the mulch layer is thick to smother emerging weeds effectively: a depth of 10 cm or greater is recommended.
- Regularly top-up mulch since it often settles and decomposes.
- Regularly monitor and spot spray or manually remove weeds that appear in the mulch.
- Establish desirable plants in the mulch to provide competition with weeds.

Mulches may assist in reducing the risk of fireweed germination in and around amenity plantings, gardens, urban roadsides and other heavily trafficked areas. However, the wind-borne seeds of fireweed can be deposited on top of mulch and may grow through it.

2.10 Pests and diseases to control fireweed

A wide range of native insects and pathogens that affect native *Senecio* have been found on fireweed. The most common of these include a leaf-feeding beetle, seed-head-feeding bugs, leaf-feeding and stem-boring moths, stem- and leaf-mining and gall-forming flies, and three rust fungi (Sindel et al., 1998).

Some of these native insects and pathogens can cause localised damage to fireweed under suitable environmental conditions. For example, larvae of the native blue stem borer moth (*Patagoniodes farinaria*) ringbarks stems and has been observed to occasionally kill plants on the north coast of NSW. The native rust fungus (*Puccinia lagenophorae*) can retard growth on heavily infected plants. However, none are known to cause long-term, sustained reductions in fireweed density in pasture.

In recent years, the introduced cotton aphid (*Aphis gossypii*) has been observed by landholders to damage fireweed plants severely during winter in parts of the south coast of NSW. This insect is also a

pest of many crops grown where fireweed occurs, including melons, potatoes, strawberry, asparagus and many ornamental plant species (Graham, 2021). Since it is non-specific, attacking many crops and also spreading plant viruses, it is not viewed as a prospective control tool for fireweed.

2.10.1 Biological control

Biological control (or biocontrol) is the use of natural enemies of weeds, usually a herbivorous insect, parasite or pathogen, to reduce the weed's population density and reproductive output to levels that reduce its impacts in the invasive range. Biological control agents should not be regarded as weed eradication tools, but they ideally reduce the pressure of weed invasion in combination with chemical, mechanical, cultural, and other weed control methods. Biocontrol agents typically have the greatest impacts at sites with a high density of healthy, actively growing plants (of the target weed). This allows for the agents to build up their population, spread and reach a level where they can significantly damage the weed.

As of May 2023, there are currently no biological agents available for fireweed control in Australia. Box 2.1 details the extensive research that has been undertaken to date.

Box 2.1 Fireweed biocontrol research

Investigations into biological control of fireweed have been underway for over 20 years. A major challenge has been understanding where fireweed in Australia came from and which other *Senecio* it is related to (for agent selection and host testing).

Genetic studies have identified that fireweed in Australia is likely to have originated from the KwaZulu-Natal region of eastern South Africa (Scott et al., 1998; Radford et al., 2000). Knowing the origin has tightened the focus of searching for potential biocontrol agents.

Genetic studies have also helped quantify how similar or dissimilar fireweed is to other *Senecio* species (Schmidt-Lebuhn et al., 2022a). This has helped to prioritise which Australian *Senecio* species should be included in host specificity testing.

Research has found that South African strains of the rust fungus *P. lagenophorae* are less virulent than forms of the same rust already present in Australia (where it is considered native). This indicated there would be no gain in introducing new forms of the rust (McFadyen and Morin, 2012).

Studies into insects found on fireweed in its native range have been completed (Egli and Olckers 2015; 2020). Candidate biocontrol agents prioritised for further investigation have included a root-feeding flea beetle (*Longitarsus basutoensis*), a stem-boring weevil (*Gasteroclisus tricostalis*) and a stem-boring moth (*Metamesia elegans*). Unfortunately, host testing found that the flea beetle feeds on a range of *Senecio* species, including Australian species, rendering it unsuitable for further consideration as a biocontrol agent. The current research focus is on the stem-boring weevil.

Dani Egli University of KwaZulu-Natal

Larva of the stem-boring weevil Gasteroclisus tricostalis.

Peter Jones, CSIRO

Adults of the stem-boring weevil Gasteroclisus tricostalis.

Chapter 3

Developing a weed management plan

'At a glance'

- **Planning helps you prioritise what actions are needed to protect and develop your property.**
- **A property weed management plan determines priority actions to prevent new weeds and manage the spread and impacts of existing weeds.**
- **This chapter describes a simple way of developing a property weed management plan.**
- **The chapter also provides guidance on planning community-led and large (landscape-scale) weed management programs.**

3.1 Introduction

Planning is one of the most important steps in weed management. Although it is tempting to jump straight in, having a planned approach to managing fireweed (and other weeds) on your property will help ensure what you do is effective, efficient and achievable. A planned approach keeps one eye on the big picture of what goals you have for your property, and the other on the detail of what priority actions you need to do and when – in order to work towards those goals. It helps you judge whether you are on track in reducing the impacts and spread of fireweed or whether you might need to change tactics.

Having a plan means your day-to-day activity is focused on achieving long-term outcomes.

Property planning can occur at various scales (Figure 3.1).

Figure 3.1 Three examples of property plans.

A **property management plan** or a farm business plan takes a holistic view of the economic, environmental and social aspects of running a property. It allows for a self-review of the property's resources (natural, financial, people, infrastructure, livestock), limitations to these resources, external influences, opportunities, and options for improvement. Property management plans are important for both commercial and lifestyle properties.

A **property biosecurity plan** focuses on minimising the threat posed to livestock, cropping and natural resources by new and established weeds, pests and diseases.

A subset of biosecurity planning is a **property weed management plan,** which is the main focus of this chapter.

Preventing and/or controlling fireweed and other weeds requires a long-term commitment. Having a property weed management plan allows you to follow a strategic approach that:

- prioritises the use of limited resources
- identifies the best control methods and their timing, thereby increasing your chances of success
- coordinates activities with your neighbours
- meets your legal obligations (where applicable)
- incorporates weed management tasks into broader property planning
- undertakes monitoring to gauge success and revise the plan as needed.

Refer to Chapter 5 (Section 5.6) for weblinks to property, biosecurity and weed management planning information and tools.

While this manual is about fireweed, it is good practice to consider all weeds, and how to align their management, in the one property weed management plan. Focusing solely on fireweed risks missing actions required for other weeds of equivalent or even greater impact. This includes declared weeds for which a legal requirement to control may exist in your area.

Hence, the following information is about weeds in general, with some specific examples given for fireweed.

3.2 Developing a property weed management plan

Key information sources for this section: Sheehan and Potter (2017), CRC AWM (2004), LLS South East (2016).

A **property weed management plan** (hereafter 'weed plan') outlines priority actions needed to prevent new weeds and control the further spread and impacts of weeds that are established on the property. Components of a weed plan include:

- stocktake of weeds present on the property and possible future weed incursions
- map of weed locations, spread pathways and assets at risk on the property
- analysis of options to manage key weeds
- consideration of property goals and weed management constraints and opportunities
- plan of priority weed management actions to be performed throughout the year
- monitoring effort, cost and effectiveness of control methods
- annual review and revision of the plan.

A good weed plan is one that provides a clear path to your management goals, allowing for flexibility and refinement along the way. Consideration should be given to *why* you are managing these weeds, because this will inform your overall goal.

A weed plan does not need to be lengthy or complicated; rather, it should be realistic in terms of what you can feasibly achieve each year. Effective control of weed infestations can take many years, so the plan should be long term.

Box 3.1 summarises the steps involved in developing and implementing a weed plan, with a checklist for each step. Initial assessment of the weed situation (Step 1) and management options (Step 2) informs priority actions to go in the plan (Step 3). While implementing the plan (Step 4), make observations and keep records to inform an annual review of the plan (Step 5).

Box 3.1 Checklist to assist in the development of an annual property weed management plan.

STEP 1 – ASSESS THE WEED SITUATION

- ☐ List major weeds present or nearby
- ☐ Create a property map, including paddock boundaries, property assets and any hazards
- ☐ Map weed distribution and density, plus pathways of weed spread

STEP 2 – ANALYSE WEED MANAGEMENT OPTIONS

- ☐ Research control options for each major weed
- ☐ Determine each weed's strategic management objective
- ☐ Identify priority control areas

STEP 3 – DEVELOP A PROPERTY WEED MANAGEMENT PLAN

- ☐ Decide on long-term goals for the property
- ☐ Identify constraints and opportunities
- ☐ Develop an annual plan of weed management actions

STEP 4 – IMPLEMENT THE PLAN

- ☐ Implement, observe and learn
- ☐ Keep records

STEP 5 – ANNUAL REVIEW OF PROGRESS

- ☐ Evaluate success of weed control measures
- ☐ Revise annual plan, including follow-up controls needed

3.2.1 STEP 1. Assess the weed situation

The first step is to understand the scale of the weed problem on your property. Conduct a survey of weed distribution and density in paddocks and around infrastructure (e.g. farm tracks, sheds, stockyards, stock watering points, fence lines). Weeds present in areas surrounding the property should also be noted.

List the major weeds present on property and surrounds

Compile a list of what major weeds are present. These are weeds on the property that are currently causing, or have the potential to cause, serious economic, environmental and/or social impacts. Also list other major weeds present in the local area but not yet on your property. Talking to your local weed officer, neighbours, agronomist, Landcare officer or other sources of advice will help build your understanding of local and regional weed threats. Also consider weeds that may be brought to your property from long distances, through such pathways as purchased fodder, livestock or machinery.

Various online resources list and identify major weeds, including state departments of primary industries (e.g. NSW WeedWise weeds.dpi.nsw.gov.au/) and NRM regions (e.g. North Coast LLS 'Weeds of the North Coast of NSW' www.lls.nsw.gov.au/help-and-advice/pests,-weeds-and-diseases/weed-control/weed-identification-and-management/weeds-of-the-north-coast-of-nsw).

Map weed infestations, key assets and spread pathways

A map of weed distribution on your property should aim to show:

- location, extent and density of weed infestations
- property and paddock boundaries
- location and types of assets
- weed spread pathways, such as water courses, roads and stock camps
- any safety hazards.

Obtain a map of your property, either as hard copy or in a digital format that you can add GPS locations to using a smartphone. Ideally, the map should have paddock boundaries and other property features clearly marked. A map does not need to be complex; the goal is to create a visual representation of the property and weed infestations so that everyone working on the property, now or in the future, can find their way around and follow a logical and strategic approach to weed management. A hand sketch can work for small properties, while a simple, computer-generated map may be better for larger properties.

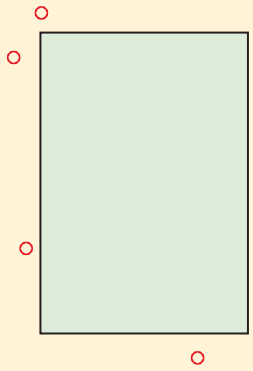
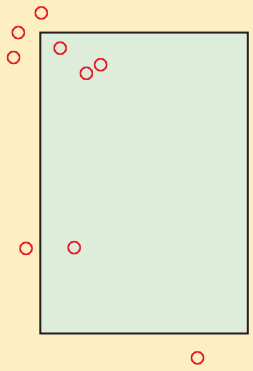
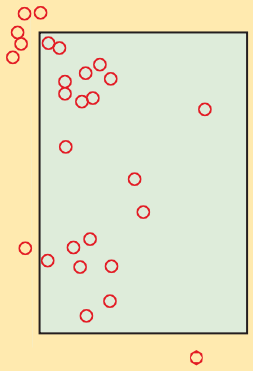
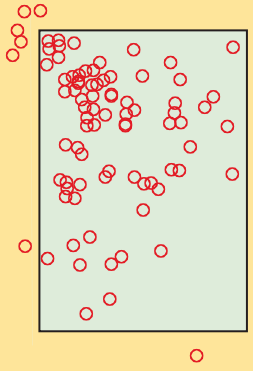
Walk or drive over your property and determine the presence of weeds in each paddock (or part thereof). Draw a 'mud map' for each paddock and record locations of weeds, transferring this to your property map later. Or take GPS readings to record the boundaries of patches of weeds or point locations of individual weeds.

Which weeds to record will be guided by your weed list; but also add any new weeds detected. Since different weeds are more obvious at different times of year, you should repeat this process seasonally to produce a thorough property weed map. For example, fireweed is easiest to detect when it has started to flower.

Record the locations of infestations of **weeds** as areas on the property map. Also record their density so you can judge in future years whether your weed plan is being successful. Typical categories for recording weed density are 'absent', 'rare', 'light', 'medium' or 'heavy'. These are described in Table 3.1 and further detail is given in McNaught et al. (2008).

Map property **assets** to help define management goals and areas that will benefit the most from weed prevention and control. Such assets may also require extra care when undertaking weed control to limit any off-target damage. Examples of higher value assets include the most productive paddocks, significant biodiversity areas, property infrastructure, and historical and cultural sites.

Table 3.1 Strategic management objectives and actions required for different stages of weed invasion.

				
Stage of invasion	**Absent** ▪ Absent: not known to be present on the property (but may be present in the local area)	**Early stages of invasion** ▪ Rare (< 1%): isolated individual plants ▪ Low risk of reinfestation from neighbouring areas	**Scattered to frequent** ▪ Light (1–10%): scattered patches and isolated plants ▪ Or medium (11–50%): frequent patches with isolated plants commonly interspersed ▪ Large areas of the property are still generally free of the weed	**Widespread and dense** ▪ Heavy (> 50%): large, dense infestations ▪ Weed can be found across most of the property
Management objective	**PREVENT** ▪ Limit arrival onto the property to stop it becoming established	**ERADICATE** ▪ Eliminate all plants, including propagules (seeds and vegetative)	**CONTAIN AND REDUCE** ▪ Prevent further spread on the property by eliminating outlying infestations and reducing density of the core infestation/s	**MANAGE IMPACTS** ▪ Reduce weed density to limit impacts on high-value assets
Management actions required	**Property biosecurity** ▪ Prevent new weeds arriving **'Seek and destroy'** ▪ Ensure ongoing property surveillance for and response to new weed incursions ▪ Conduct coordinated control program across infested properties where a high impact weed is new to the district	**Delimitation** ▪ Ensure frequent surveillance to map all known infestations **'Seek and destroy'** ▪ Search for and remove all plants prior to reproduction **Property biosecurity** ▪ Implement hygiene practices to prevent spread across the property	**Spread prevention** ▪ Implement hygiene protocols and other measures **Control** ▪ Conduct ongoing integrated control program to reduce density in areas where firmly established **'Seek and destroy'** ▪ Search for and remove all plants prior to reproduction for outlying infestations	**Spread prevention** ▪ Implement hygiene protocols and other measures to prevent spread off-property **Control** ▪ Conduct ongoing integrated control program to reduce density to keep impacts at an acceptable level ▪ Protect high-value assets at risk from weed impact

Identify and map **pathways** for weed spread on the property, for example, roads and tracks, water courses, livestock yards and feeding areas, and linear easements such as stock routes and powerlines. With fireweed and other wind-dispersed weeds in mind, map **risk areas** where the prevailing winds and topography are likely to deposit weed seeds.

When undertaking mapping and weed control, it is important to identify any **safety risks** to prevent potential injuries, for example, areas that are steep or have hidden ground hazards, rendering them unsuitable for driving across with a boom sprayer.

Figure 3.2 gives an example property weed map, which in turn is used to inform examples for other steps.

Establishing a baseline of current weed status

Using information collected on weed distribution and density at the planning stage, you can establish a baseline. You can use this baseline to record change and assess the effectiveness of management outcomes over time. Each time you produce an updated map and record weed density, you can compare it against your original baseline map.

You can also establish photopoints, where images are taken at the same spot at the same time each year. This ensures a long-term photographic record of change in weed distribution and density over time.

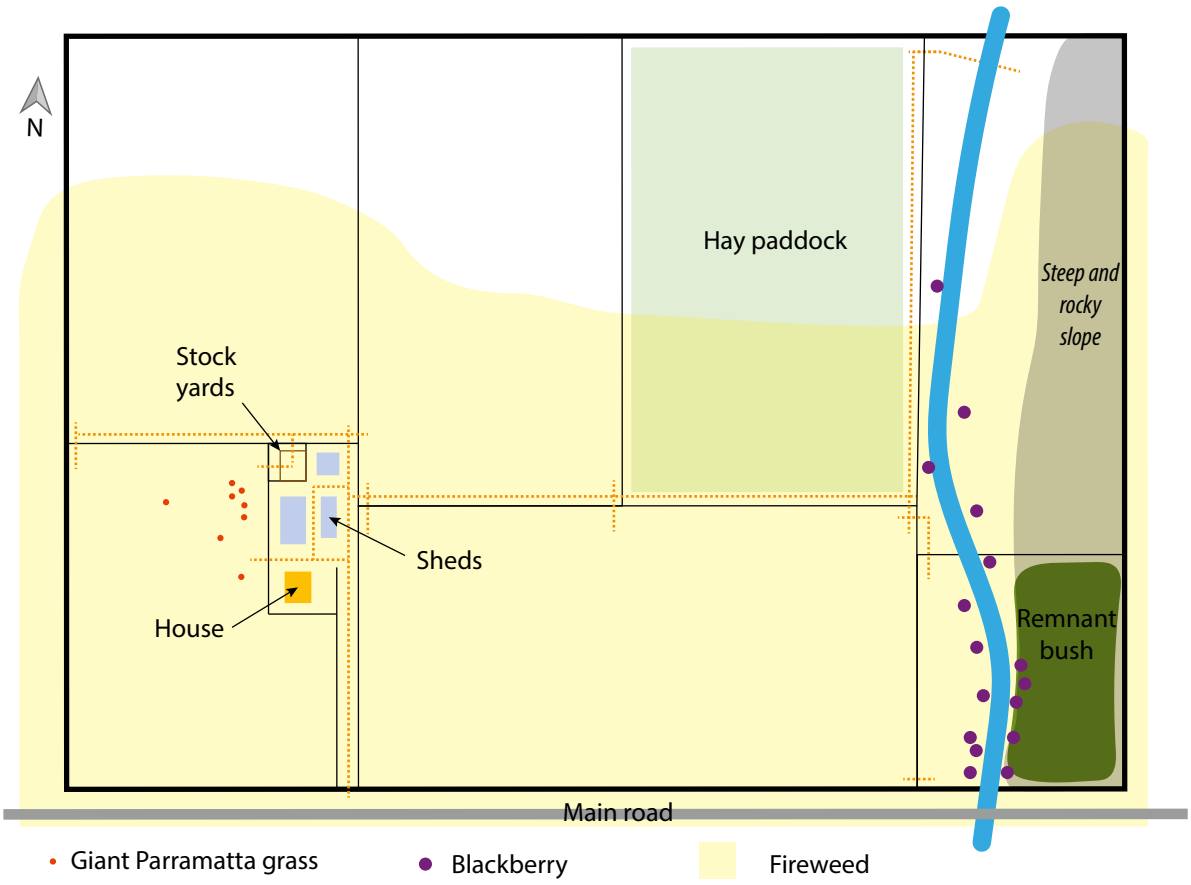


Figure 3.2 An example property weed map showing infestations of fireweed (widespread), giant Parramatta grass and blackberry.

3.2.2 STEP 2. Analyse weed management options

This step requires you to consider the weed control options and strategies available for different parts of your property, based on the weeds identified in Step 1.

Control options for weeds

Conduct some online research on the biology, impacts and management options for the major weeds identified in Step 1. A range of information is available from government (state, territory, local), NRM and farming websites. You should also seek advice from your local weed management authority. Describe the weeds' overall distribution on the property, likely impacts if not controlled and pathways of spread, as well as potential ways to prevent and control them.

It helps to 'think outside the box' in terms of what control options you could adopt. For example, for fireweed some property owners have decided to run sheep in preference to using herbicides. You should also be aware of the limitations of control options. These may include off-target effects on desirable plants, restricting livestock access to treated paddocks, lack of suitability for non-arable areas and expense. Table 2.1 in Chapter 2 compares the pros and cons of different prevention and control measures for fireweed.

Weed management strategic objectives

Strategic weed management objectives relate to the stages of invasion of the weed being controlled and comprise the following: **prevent**, **eradicate**, **contain and reduce** and **manage impacts**. These objectives are described in Table 3.1, including the general actions needed to achieve them.

To decide on a feasible management strategy for each weed, consider:

- the distribution of major weeds on the property (from the mapping)
- how they can be cost-effectively prevented and/or controlled
- potential impacts of the weed on property assets.

Eradication – is it feasible?

Note that eradication is a term often used but rarely achieved in practice for weeds. Successful eradication requires the elimination of every individual plant and propagules (e.g. seeds, bulbs) in a defined area, plus no further reintroduction from outside the area. This is extremely difficult to achieve. Generally, eradication is only possible where the weed is a recent incursion.

Factors required for successful weed eradication on a property:

- Weed distribution and density is rare across the property.
- All infested areas are known.
- The chance of reinvasion from surrounding areas is unlikely.
- Newly emerged plants are easily detected before they set seed (and/or vegetative propagules, for some types of weeds).
- Individual plants are easy to kill, including those that regenerate vegetatively.
- The weed has not been there for many years and therefore has not formed a large soil seedbank.
- Seeds do not persist in the soil for many years.
- Sufficient 'people power' is available for regular searching (e.g. fortnightly to monthly) to find and remove all plants before flowering.
- This 'seek and destroy' effort can be maintained each year for many years until there is no more emergence from the soil seedbank.

Priority control areas

The number and extent of weeds on your property is often too much to tackle all at once. In general, it is best to prioritise new, small or outlying infestations, then areas with high risk of spread, then protection of high-value assets (Table 3.2).

Table 3.2 General order of priority for where to control weeds.

PRIORITY 1	**New, small or outlying weed infestations** These should be intensively controlled (and eradicated where feasible) to stop them becoming large infestations with persistent seedbanks.
PRIORITY 2	**Areas with high risk of weed spread** Areas such as farm tracks, parking and visitor areas, stockyards, dams, troughs, gateways and watercourses should be targeted for weed control to reduce the risk of weed spread causing new infestations on the property. Also consider weeds within paddocks that present a high risk of further spread on the property by such means as livestock, machinery or conserved fodder.
PRIORITY 3	**High-value assets** Where weeds are widely established, focus on reducing current and future impacts on important assets. For example, look after the most productive paddocks and the best patches of bush. Maintain access to and functioning of property infrastructure such as fences and dams.

However, you need to weigh up addressing the immediate impacts from widely established weeds versus preventing the potential impacts of new or emerging weeds. For example, fireweed may be widespread across your grazing paddocks, and you will need to undertake broadscale control to keep its density low.

It is important not to take on too much from the start, particularly if you lack experience in weed control or in managing a particular weed. Choose a small area that can be regularly observed to gauge whether your control technique is working satisfactorily; consider ways to achieve an even better result and build confidence for taking on larger infestations.

Table 3.3 provides an example of how the information and analysis from Steps 1 and 2 can be combined to decide on the management approach to be adopted for each priority weed.

Table 3.3 Example approach to analysing weed management options on a property.

		FIREWEED (*Senecio madagascariensis*)	GIANT PARRAMATTA GRASS (*Sporobolus fertilis*)	BLACKBERRY (*Rubus fruticosus*)
CURRENT STATUS		*Light cover in most paddocks.*	*Rare – found spotting across house paddock. Likely recent incursion from hay.*	*Light – scattered along creek and creeping into remnant scrub.*
RISK OF IMPACT		*If dense, then risk of cattle poisoning and pasture among fireweed not being eaten. Risk of contaminating hay (seed and toxicity).*	*Risk of making seed contaminated hay. Can become dominant over palatable pasture grasses.*	*Reduces access, amenity and biodiversity. Potential to invade lower pastures.*
ASSETS AT RISK		*Already in hay paddock.*	*Hay paddock. Grazing paddocks in general.*	*Creek line, scrub and steep grazing paddock.*
PATHWAY RISKS		*Wind-blown seed from south-west. Spread by mowing if in flower.*	*Hay. Cattle movement onto and across property. Spread by mowing if in flower.*	*Birds, floods, foxes.*
PREVENTION AND CONTROL OPTIONS	Spread prevention	*Windbreaks, machinery hygiene, control around sheds and tracks.*	*Clean down vehicles and machinery. Restrict cattle movement.*	*Difficult to stop seed spread.*
	Competition	*Establish and maintain competitive pasture.*	*Establish and maintain competitive pasture.*	*Establish and maintain competitive pasture and riparian native plants.*
	Grazing	*Don't overgraze pasture. Introduce a 'weeder' mob of sheep.*	*Don't overgraze pasture.*	*Consider goats as a temporary measure if gets out of hand.*
	Herbicide	*Boom spray early in season. Spot spray isolated flowering plants.*	*Spot spray (though risks missing small plants compared with boom spray).*	*Spot spray Roundup Biactive near creek when is actively growing, but likely to need several follow-up sprays.*
	Manual removal	*Hand pull before seed set.*	*Chip out and bag.*	*Difficult as get regrowth from roots.*
	Cultivation	*Risk of stimulating germination and soil erosion.*	*Risks damage to pasture.*	*Not applicable.*
	Mowing/ mulching	*Risk of seed spread if flowering.*	*Risk of seed spread if flowering and poor control achieved.*	*Not applicable.*
	Biological control	*None available.*	*Nigrospora crown rot if weed becomes widespread.*	*Rust doesn't kill plants.*
	Other	*General biosecurity obligation.*	*General biosecurity obligation.*	*General biosecurity obligation.*

Table 3.3 continued on next page/…

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MANAGEMENT OBJECTIVE	MANAGE IMPACTS ▪ *control*	ERADICATE ▪ *delimitation* ▪ *seek & destroy* ▪ *property biosecurity*	CONTAIN & REDUCE ▪ *contain further spread* ▪ *seek & destroy new plants* ▪ *control*
CONTROL AREAS	*Stockyards, holding paddock, hay paddock.*	*All known infestations. Monitor farm tracks, fence lines, all paddocks (!), roadside and remove any plants found.*	*Creek line. Look out for spread in pasture and scrub.*
MANAGEMENT APPROACH	*Present across the property and in district. Keep density at a light level through competitive pasture, grazing management and use of herbicides. Need high intensity control in hay paddock. If density increases, then may need to consider introducing sheep.*	*Spreads easily on stock and machinery so must remove plants prior to flowering. Spot spray and chipping. Regular searching of other paddocks – especially hay paddock. Buy certified-free hay. If found in more paddocks then will have to shift strategy to 'Contain & Reduce'.*	*If glyphosate not giving level of kill needed, then talk to weeds officer about other herbicide options for riparian areas.*

3.2.3 STEP 3. Develop a property weed management plan

This step brings together the priority actions for the weed plan and aligns them with your long-term property goals and available resources. Table 3.4 provides an example of a simple annual property weed management plan.

Property goals

What are the long-term goals for your property? For a commercial farm, the focus is often on ensuring productivity, sustainable use of natural resources and market access for products. For a lifestyle property it may be more about the amenity of living in a rural landscape, the ability to run a few grazing animals, and valuing and restoring the local environment.

Setting a long-term goal highlights what you value most about your property. In turn, this influences your weed management priorities – whether they are economic, environmental and/or social impacts that you wish to prevent and manage.

Constraints

What constraints will limit or direct what you can do to prevent and manage weeds on your property? Consider such things as finances, people, infrastructure, equipment, natural resources and business. Examples of possible constraints include:

- funds to spend on weed control
- cost of individual control options
- time available when weed control needs to occur
- skills and knowledge

- availability of equipment
- availability of labour
- accessibility of areas of your property
- work health and safety considerations
- physical ability to use certain control methods
- preferences on using herbicides
- legal requirements to control regionally declared weeds
- avoiding unintended damage (e.g. risks of herbicide drift, contamination of waterways, soil erosion)
- community expectations to control certain weeds
- lack of feasible control measures available
- natural dispersal of weeds onto the property.

Opportunities

Are there ways you can make weed prevention and control more efficient or effective? It may be possible to share equipment with a neighbour or split the cost of hiring a spray contractor. There may be multiple weeds that can be controlled by the same method. Opportunities may exist to apply for grant funding to undertake an initial ('primary') control of a weed infestation, helping to protect regional biodiversity or productivity. Joining a local Landcare group may help you share the load and provide access to expertise and equipment. Other forms of assistance may be available through your weed management authority, local council or NRM organisation.

Annual plan of action

Reviewed annually, the weed plan provides a way to record what you need to do to tackle your highest priority weeds. At its simplest, a weed plan can be a calendar of actions required at certain times of the year. It also indicates where on the property these actions need to be done.

Consider your long-term goals for the property, analysis of the weed situation and management options, the constraints you are working under and the opportunities to address these. Draft a calendar of actions you can feasibly undertake to address your priority weeds in specified areas of the property.

Think about the timing of these actions in relation to each other and other property activities. Are there conflicts? Are there further efficiencies you can implement to save costs or time? The plan does not need to be perfect; it can continue to be refined until you achieve something workable for the year.

Seek advice and input from weed management experts (e.g. local weeds officer, farm advisor, Landcare officer) and neighbours to ensure that your priority setting is sound and will align, if needed, with others' weed control activities.

While this is an annual plan, it is important to think ahead to what you will need to do in the following years to progress further in reducing your weeds. Weed management is a long-term investment and cannot be achieved in one year only.

A plan is a guide, and you still need to be flexible with your timing to adapt to unforeseen circumstances such as drought, floods or other extreme weather events. You may also need to alter timing of weed management activities based on other factors, such as varying seasonal conditions or other urgent property management needs that could arise.

Table 3.4 An example annual property weed management plan. In order to save space, this example focuses largely on fireweed and includes only those months that require actions.

PROPERTY GOAL/S	*To have a profitable cattle enterprise to supplement off-farm income.* *To keep the property in good condition as an asset.*
Implications for weed priorities:	*Focus on protecting pastures for cattle production. Avoid new weeds becoming established. Manage established weeds so they don't become dominant. Work with neighbours on shared weed issues. Look after the remnant bush and creek habitat.*
CONSTRAINTS:	▪ *Time: working full time off-farm so limited to weekends and after hours.* ▪ *Some steep, rocky areas difficult to access for spraying, and pasture grows poorly so more vulnerable to weeds.* ▪ *Withholding periods after weed spraying for cattle.* ▪ *Risk of weeds blowing or washing in from next door.* ▪ *Need to be careful with herbicides around the remnant bush.* ▪ *Can get very wet in lower paddocks after rain periods, making vehicle access difficult.*
OPPORTUNITIES:	▪ *Agist cattle next door (on non-weedy pastures) during withholding period for sprayed paddocks.* ▪ *Potential grant funding to fence off, control weeds and revegetate creek – so less weedy in long term.*

Month	Weed/s	Action/s	Priority control areas	Notes
Jan	Fireweed	*Rotate grazing to keep pasture dense into autumn.*	*Paddock 6 (steep and shallower soil so more prone to bare patches).*	*Keep up rotational grazing late summer into autumn to maintain groundcover.*
Mar	Fireweed	*Monitor in pastures for germination flushes. Get quotes from spray contractors.*		
Apr	Fireweed	*Spray seedlings (bromoxynil).*	*All pasture paddocks and hay paddock.*	*8 week withholding period so need to agist cattle – if can't then skip 2 least infested paddocks.*
Jun	Fireweed	*2nd spray.*	*Hay paddock (needs to be clean). Consider any paddocks missed in April.*	
Aug	Pasture weeds	*Fertilise pastures so competitive growth in spring.*	*Soil test to see which paddocks need.*	
Sep	Fireweed	*Spot spray.*	*Hay paddock (needs to be clean).*	
Oct	Pasture weeds	*Decide which paddocks will need pasture improvement next year. Start planning for weed control needed to aid pasture establishment.*	*Maybe paddock 6? House paddock also if off-target damage from controlling giant Parramatta grass?*	*Do an assessment of pasture health in all paddocks.*
Year round	New weeds	*Property biosecurity plan – prevention, hygiene, seek and destroy new weeds*	*Vehicle and machinery entry. Around sheds, tracks, hay feeding areas etc.*	*Constant vigilance!*
Next year		*Need to weigh up cost of spray contractor versus purchasing equipment (if I have time to do the spraying?).*		

3.2.4 STEP 4. Implement the plan

Refer to your plan regularly as you implement your annual weed management program. You could program actions into an electronic diary (e.g. on your smartphone) to enable pop-up reminders. Use your plan to keep on track, stay motivated and remind you why you are managing weeds. Remember that the plan is a high-level summary of what you are aiming to do and that each action will likely need further division into tasks.

Learning from doing

Use the implementation of your weed plan as an opportunity to observe the cost-effectiveness of your actions, so that you can make future improvements to your plan and methods of weed management. Treat it as a continuous learning exercise and challenge yourself regarding how it could be done better. Consider the following for an action taken:

- Did it cost more or take more time than expected?
- Did you achieve a satisfactory level of weed kill? (see Box 3.2)
- Did you have scheduling clashes between weed management and other important property activities and needs?

Make diary notes throughout the year on what you have observed and learned. Failures are just as important to record as successes.

Box 3.2 A simple way of measuring weed kill

1. Go to the parts of a paddock where the weed has been dense.
2. Looking in from the edge of the treated area, choose a point in the distance that you will walk towards in a straight line transect.
3. Every five steps (or more if the weed is sparse) examine the weed closest to your leading foot.
4. Score the individual weed for level of kill (e.g. dead = 5, stunted/yellowing/burnt off = 3, healthy = 1).
5. Do this for 10 weeds along the transect.
6. Repeat with 4 more transects at least 10 m apart.
7. Average the 50 weed scores.

John Virtue

Assessing herbicide kill

Time this exercise according to how long you expect the weed control method would normally take to kill the target weed, at that time of year. If the level of kill is less than expected, then repeat your assessment in a fortnight to assess whether the result was due simply to a delay in the treatment working. This approach can also be used to examine off-target damage in desirable plants (e.g. pasture plants).

Establishing photo monitoring points at selected locations throughout the treated area can assist in visually recording changes over time and the impact of your weed control efforts. Photopoints tend to be more useful for larger, perennial weeds that are more obvious in photographs than annual weeds. Various factsheets are available on how to set up photopoint monitoring (e.g. NRM South (nrmsouth.org.au/wp-content/uploads/2014/08/Photo-Monitoring-Fact-Sheet-NRM-South.pdf), Eyre Peninsula Landscape Board (cdn.environment.sa.gov.au/landscape/docs/ep/eplb_photopoint_monitoring_factsheet.pdf)).

Record keeping

In line with the 'learning from doing' approach, log your activities as you undertake them. Keep records of:

- all costs
- time taken
- weed locations
- control methods
- areas treated and their size
- equipment and supplies used (e.g. herbicide volume)
- weather conditions at time of control
- level of weed control achieved.

3.2.5 STEP 5. Annual review of progress

An annual review of the weed plan is recommended to inform what changes are needed for the following year. For each weed targeted in your plan, ask yourself broad evaluation questions such as those outlined in Table 3.5. Draw on the monitoring undertaken in Step 1 to measure these questions against a baseline.

Given most weeds require multiple years of follow-up control, you may not be making major changes to your plan initially (unless a control method is clearly not working). When substantial gains have been made against target weeds, usually after at least several years, you can shift your focus to other weeds that had been lower priorities.

If weed control has been poor, then you need to determine why. Seek professional advice on what changes are needed to your control techniques and your broad management approach. Weed management is a long-term undertaking, and you want to be confident that the time and money invested will give you effective results.

Follow-up

As fireweed is an annual weed emerging from the soil seedbank, follow-up control will generally be a repetition of the same control actions year to year.

For other weeds, such as large woody weeds, the first year of 'primary' control is usually the most intense. Seedlings or regrowth in successive years will still require follow-up control, but this could employ different methods, and less time might be required. This should be factored into the next and subsequent years' weed plans.

Table 3.5 Example annual review questions.

Review questions	Monitoring techniques that can address questions
Has the extent (area) of the weed infestation increased or reduced?	Update the property map to record any changes in weed distribution or any new weeds.
Has the density of the weed increased or reduced?	Check against categories in Table 3.1.
Are desirable plants recovering?	Key pasture species can also be assessed using the categories in Table 3.1.
Which control methods have been most successful?	Measure and compare weed kill according to the method in Box 3.2.
How much is control costing?	Calculate costs/ha from your record keeping, including cost for your time.

3.2.6 Repeating the annual planning cycle

The second and subsequent repetitions of the annual planning cycle should become progressively quicker to write. Step 5 in the previous cycle will have informed any updates that need to be made to describing the property's weed situation (Step 1). Any new information on weed control techniques, plus observations on how well the methods worked in the previous year, will inform an update to the analysis of weed management options (Step 2). The previous year's plan will provide a template for drafting the revised plan (Step 3).

Every 3–5 years it is valuable to spend more time assessing the current state of weed prevention and management on your property. Question whether you are truly on track and making substantial progress. Involve others in the process to act as peers and provide new insights and observations.

If the planning process is working well for you, then inform and encourage others to do the same and make broader district gains on weed management. The next section provides tips on how to achieve a coordinated approach to weed management across neighbouring properties.

3.3 Working together on weeds

Weeds do not respect property boundaries, and a coordinated approach with neighbours can make for more effective control programs. Approaches can be implemented at different scales (local, landscape) and informally or formally.

Local – informal

This can be a grass roots approach in which a rural neighbourhood chooses to work together on a common weed problem. Such cooperation can be quite informal, for example:

- welcoming new landholder arrivals and providing them with information on local weed problems
- organising paddock walks to discuss control methods
- sharing weed control equipment
- agreeing to let each other know if you observe a weed outbreak on your neighbour's property
- having an in principle agreement that neighbours may hand pull the occasional weed appearing just over the fence.

Local – formal

A more formal approach is to form a weed-focused community group. Recommendations on how to achieve this are detailed below by the Australian Centre for Culture, Environment, Society & Space (ACCESS), University of Wollongong.

Key points are:

- establishing an agreed, common goal for the weed in the local area
- defining the boundaries within which the weed will be tackled
- creating an achievable workplan
- sharing the organisational and weed management load
- documenting and promoting what has been achieved.

Regional

The next level of collaboration is a district coordinated control program run by a weeds officer to tackle a regional priority weed. Understanding and developing social relationships is vital for planning and implementing such a program. Guidance to help establish the social context is provided by ACCESS below.

Key points are to:

- tap into existing networks to reach land managers
- understand community diversity, capacity and views concerning weed management
- build community support for viewing the weed's control as a priority
- document where the weed is and where it could spread to – who is affected now and who is at risk?
- establish what has been successful regarding timing and methods of control
- draft a regional weed management plan that includes both social and technical considerations
- establish a steering committee to oversee the plan's implementation.

Better together: building networks and shared objectives to achieve landscape scale control

ACCESS
Australian Centre for Culture, Environment, Society & Space

UNIVERSITY OF WOLLONGONG AUSTRALIA

This section provides tips for property managers and weed management professionals to leverage and coordinate communities to achieve landscape control.

Tips for property managers

There are many examples across Australia of property managers successfully working together across properties to reduce their shared weed burden. These tips come from observing community groups working with a diverse range of weeds.

1. **Identify a group of people** concerned about the target weed and passionate about working together. Locate them through a community meeting, social barbeque, Facebook group etc.
2. **Develop a common goal** e.g. prevent the weed from going to seed, reduce local spread, local eradication.
3. **Define a clearly bounded area** to work together on weed control, e.g. a river corridor, small valley, several adjoining properties, or a rural residential estate. Define an area consistent with the amount of time and resources you have to invest in weed management; too large an area can mean results take too long to see, and motivation can wane.
4. **Develop a plan to prioritise your efforts** within the clearly bounded area. This may involve focusing on the lightest infestations and the outliers, and then working in towards the densest infestation. Include:
   - the activities the group will use to address the weed, e.g. working bees, individuals looking after specific sections, employing a contractor to reach difficult-to-access areas or to manage particularly dense infestations
   - the frequency (e.g. weekly, monthly) and timing (e.g. Tuesdays) of any group work
   - whether there are any native animals or plants currently benefiting from the weed – this ensures your management activities are undertaken sensitively

   Ensure you have all landowner's permission (and involvement) before commencing planning and work.
5. **Ensure a social component to activities** – keep motivation going through social activities, e.g. sharing afternoon tea at the end of a working bee. This enables groups to reflect on what they have achieved together, beyond what they could have achieved alone; determine their plan's effectiveness; and whether the clearly bounded area is too big or small.

6. **Share the load** – organising working bees, contractors and other weed control activities can become an administrative burden that undermines the group's longevity. Assign group roles based on experience, expertise and interest in key areas such as:
   - communications – for sharing information about group activities on social media or via email
   - recruitment – for inviting and welcoming new people to the group
   - grant writing – to apply for funding to support group activities
   - plant identification – to teach members to identify the target weed(s) and other plants.

   Also share the weed control load. Groups of neighbours might rotate work on each other's properties, finishing each rotation with a barbecue or other social activity.

7. **Document your journey** e.g. photos or brief written accounts of weed management impacts, to showcase your successes; develop a collective sense of achievement; and attract new recruits. Recording lessons learned may also be useful for other groups.

8. **Connect with others** – make connections with groups addressing the same, or similar, weeds in neighbouring areas or further afield. Share your knowledge and resources and the activities and decisions that have (and haven't) worked. Link with local, state government and non-government organisations for potential funding and grants, resources and support.

Tips for weed professionals

The following points guide professional weed control and project officers in understanding and working with their local communities to develop coordinated weed management programs for priority regional weeds.

1. **Know who – identify, understand and encourage social relationships**

   Identify existing land manager networks.

   Networks, including those that are not weed specific, may be leveraged for communicating weed-related messages and events, e.g.
   - Farming networks – producer groups, sustainable farming, restorative agriculture
   - Volunteer networks – Landcare groups, community associations, Rural Fire Services
   - Agronomist and other advisor networks
   - Local government
   - Regional NRM bodies (e.g. Local Land Services), regional managers of reserves (e.g. conservation, water) and existing cross-agency bodies (e.g. roadside environment committees).

   Understand the local community.

   Understanding the composition, capacities and perspectives of the community will help to determine weed control priorities, preferred control methods, underlying issues related to weeds and weed control, and where tensions are likely to emerge. Consider:
   - the proportion of land managers that are Indigenous land managers, production farmers, hobby farmers/life-stylers, government or corporate (e.g. forestry)?

- how these proportions have changed over time
- which land managers and weed management experts people currently turn to for advice
- who may be most interested in building their capacity to manage weeds.

Build trust.

Encourage formation of positive relationships among land managers and other stakeholders. Consider:

- bringing together land managers who may not know one another early on
- prioritising weed management along private and public boundaries to demonstrate commitment to being a good neighbour
- developing relationships with other relevant stakeholders with land management aspirations – e.g. Indigenous organisations and community groups – to broaden the weed management knowledge base and practice.

2. Know what and know why – prioritise your target weed relative to other weeds and land management issues

Establish the community's priority weeds.

Where does your target weed fit in relation to the list of weeds that are declared for control? What are the other key weeds of community concern? These may be different from locally declared weeds or other formal priorities. Are some segments of the community more concerned about your target weed than others?

Establish your target weed's community impacts.

What are the motivating factors that drive people in the community to control the weed? Are they to do with protecting livestock? Being a good neighbour? Caring for nature? Having a tidy-looking property?

Identify the benefits of controlling your target weed.

This includes not only reduced weed density and spread but also environmental, economic and social benefits resulting from working together on weeds.

3. Know where – where is your target weed located and most likely to spread?

Map the weed extent.

Establish where the core and outlying infestations are. The weed may be widespread in some areas, but emerging in others. Knowing its extent and density will be important to develop a plan for where to prioritise on-ground works; how to allocate resources; and to identify stakeholders in adjoining areas who could benefit from joining the initiative.

Consider any boundaries the weed crosses.

Any land tenure boundaries the target weed crosses will have management implications that will need to be considered.

- Does the target weed spread across private land or public land?
- Does it spread along corridors, such as rivers, roadsides, travelling stock routes or irrigation channels?
- Do opportunities exist to coordinate the timing of management along corridors or across boundaries for more effective management?

- Are there stakeholders whose jurisdiction spans similar boundaries to the weed who could facilitate coordinated responses?

4. **Know how – what approaches have been used to control your target weed locally?** Identifying and examining stories of previous target weed control success, failure and experimentation provides for collective learning and insights into the time and approaches needed to achieve success. Were there any weaknesses inherent in unsuccessful past efforts where land managers had given up? And how long did any successful effort take to achieve?

5. **Know when – identify the most effective time to control your target weed.** Timing is critical to successful weed control. Consider how the optimum weed control time fits with other community commitments such as sowing, harvesting, summer holidays. Will land managers have the capacity to control the target weed at certain times of year or during periods of seasonal difficulty such as floods and drought?

6. **Bringing it all together – develop a weed management plan.** Develop a landscape-scale weed management plan that brings together your understanding of both the weed and the local community. This is fundamental to leading an effective weed management program. Consider establishing a steering committee to help develop the plan, engage with diverse stakeholders, and oversee its implementation. Follow the five steps at the beginning of this chapter.

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Chapter 4

Case studies on fireweed management

4.1 Small acreage beef cattle, Broughton Village

Fireweed management objective: *Manage impacts*

- ☑ *timely herbicide application*
- ☑ *competitive pasture year-round*
- ☑ *strategic grazing*

Key points

- **Vigorous pasture growth is achieved throughout the year with warm season kikuyu and cool season annual ryegrass.**
- **Every autumn, half the paddocks are sprayed with bromoxynil and surface sown with annual ryegrass.**
- **Paddocks are intensively grazed then rested for six weeks.**
- **Bromoxynil has been found to impact on clover regeneration.**

Paul Carter

Paul and Sandy.

The property

Paul and Sandy Carter own 'Auburn Leigh' – a 10 ha property at Broughton Village in the Illawarra region of the South Coast of NSW. Located about 50 km south of Wollongong and 5 km from the coast, the area has a humid, warm temperate climate with mild winters and average annual rainfall of 1400 mm.

The property was bought in 1986 and has been developed into a small acreage beef cattle property running Red Angus. The property is a supplement to off-farm income and must pay for itself, including rates and property improvements such as fencing. With a maximum property carrying capacity of 25 head, Paul and Sandy normally have 12–13 breeders plus calves. Meat is sold direct to consumers, using a local abattoir and butcher.

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The property's pasture is predominantly kikuyu, and annual ryegrass provides winter feed. The cattle are rotated through seven paddocks, with each paddock typically grazed for around six days and then rested for up to six weeks. Around 40–50 round bales of silage are produced each spring for supplementary feed or to sell.

Paul Carter

Red Angus cattle are grazed on the property.

The problem

Fireweed was not present when Paul and Sandy bought the property – they first noticed it in 1988. Seed was thought to have blown in from other properties where it was not under control. Nowadays, fireweed is widespread throughout the district.

Paul and Sandy's initial strategy was to hand pull fireweed; however, they soon realised they could not keep up with the amount of fireweed frequently emerging in paddocks. They needed a reliable way to keep fireweed density low in their cattle pastures.

The approach

Paul built his knowledge on fireweed by attending every field day he could and keeping up to date with new information on its control. Based on this knowledge, Paul and Sandy's integrated weed management approach now concentrates on maintaining competitive pasture throughout the year, supplemented with herbicidal control of fireweed every second year.

Maintaining kikuyu

Kikuyu productivity is maintained through adequate soil nutrition and cutting after grazing. Soil testing every two years determines fertiliser and liming needs. Both fertiliser and lime are applied in spring with a tractor-mounted fertiliser spreader (also called a spinner), when rain and rising temperatures enable a good pasture growth response. PASTUREBOOSTA® fertiliser, containing nitrogen (N), phosphorus (P), potassium (K) and sulphur (S), is applied at a rate of 100 kg/ha. Liming is typically done every two to three years using 300 kg/ha of Calciprill®, a granulated product.

After the cattle have grazed a paddock for six days, it is slashed to tidy up the kikuyu for even regrowth. Any fireweed in the cut plant material breaks down before the cattle return to the paddock.

John Virtue

The kikuyu pasture in March 2022.

Spraying fireweed and sowing annual ryegrass – every second year

Kikuyu is a warm season perennial, and its growth slows during winter. Pasture productivity and competitiveness through the cool season is maintained by sowing annual ryegrass in autumn. Bromoxynil is used to spray fireweed seedlings prior to sowing. Half the property is sprayed and sown each year, so that cattle can continue to graze in untreated paddocks while the eight-week bromoxynil withholding period passes and the ryegrass establishes.

The opening autumn rains indicate when to start regular paddock walks to search for germinated fireweed. When seedlings are about 10–15 cm tall it is time to spray. In late-break years, germination is delayed and spraying is not done until June–July.

John Virtue

Fireweed is sprayed with bromoxynil when 10–15 cm tall.

Bromoxynil herbicide is applied with a boom sprayer (with a 400 L spray tank and 6 m wide boom). 400 mL of herbicide (200 g/L bromoxynil product) per 100 L water is applied at a high water rate of around 370 L of spray mix per hectare. Overall, this equates to a herbicide rate of 1.5 L/ha.

Annual ryegrass seed is surface sown in autumn at least several days after spraying bromoxynil – this avoids any damage to ryegrass seedlings from the herbicide. A rust-resistant variety of annual ryegrass is used (about half the price of perennial ryegrass seed), which provides vigorous winter growth.

Ryegrass is sown at a rate of 25 kg/ha, or higher if ground cover is sparse after a dry summer. Seed is broadcast with the fertiliser spreader. The pasture is then slashed down to cover the seeds to promote good levels of germination. CROPLIFT® 15 starter fertiliser is applied at 100 kg/ha, hand mixed with the ryegrass seed, to encourage strong early growth. In mid-winter, urea fertiliser is applied in mid-winter at 100 kg/ha, following two grazing cycles, to maintain good levels of growth. Silage is made in spring, but only from areas without fireweed.

Paul Carter

Cattle grazing on annual ryegrass pasture.

Lessons learned

The key focus for the property is achieving vigorous pasture production throughout the year. Not only does this help to suppress fireweed, but also Paul and Sandy have been able to double their stocking rate.

Future challenges

The main concern Paul has with the approach to managing fireweed is bromoxynil herbicide killing clovers. This risk increases with warmer autumn temperatures. Some naturalised clovers do persist, but a greater pasture legume component would reduce the need for N fertiliser for grass growth. Bromoxynil herbicide also kills chicory, *Cichorium intybus*, meaning this valuable perennial pasture species cannot be grown. Other registered herbicides for fireweed pose similar risks to legumes and other broadleaved pasture species. Paul would welcome a herbicide option that poses less risk of off-target damage.

Another emerging weed challenge is giant Parramatta grass. This invasive, non-palatable, perennial grass is an emerging problem in pastures throughout the region. Paul has been spot spraying each year with Taskforce® flupropanate herbicide, yet he continues to see it increase. Shifting from spot spraying to boom spraying with flupropanate is not possible because this entails a four-month withholding period for cattle grazing (rather than 14 days for spot spraying) and may also reduce kikuyu growth. Over time, giant Parramatta grass may become more of a challenge for pasture quality than fireweed, and developing ways to manage them both in an integrated manner will be critically important.

In 2022, the La Niña weather pattern resulted in rainfall of over 3300 mm – more than double the annual average. This severely restricted the ability to access saturated paddocks with machinery to sow winter–spring feed or to spray fireweed. However, it did lead to longer warm season growth from the kikuyu pastures, which enabled suppression of fireweed well into late autumn. Being aware of seasonal variation and adapting land management approaches accordingly is important in weed management.

4.2 Farming beef cattle and sheep, Bega Valley

Fireweed management objective: *Manage impacts*

- ☑ *competitive pasture year-round*
- ☑ *rotational grazing system*
- ☑ *sheep eat fireweed*

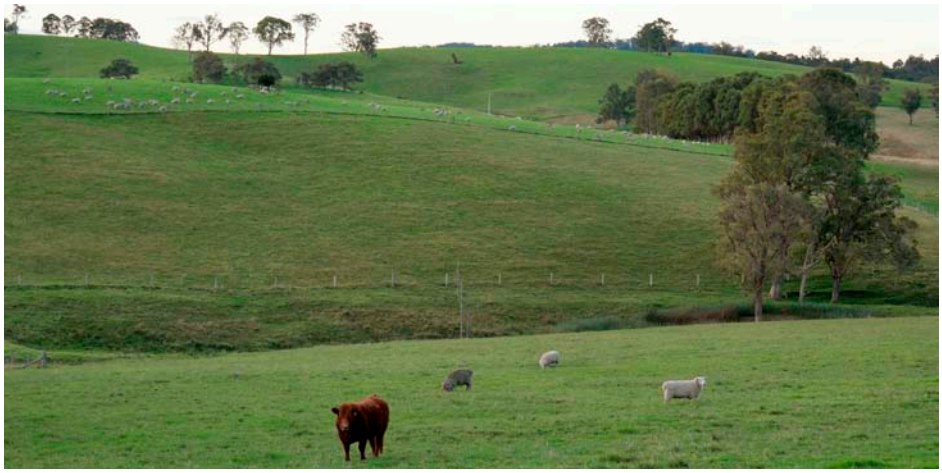
Key points

- **The property farms beef cattle and Merino sheep in coastal NSW.**
- **Herbicidal control of fireweed had become too expensive – a different approach was needed.**
- **The Merino sheep enterprise controls fireweed while producing income streams from wool and first-cross lambs.**
- **Pasture competitiveness and productivity year-round is achieved with warm season kikuyu and cool season phalaris and cocksfoot.**

The property

Noel and Marie Watson have been farming since 1972 at their 250 ha property, 'Glenayr', in the Bega Valley on the Far South Coast of NSW. The gently undulating hill country is about 10 km from the coast and receives an annual average rainfall of around 750 mm. The climate is temperate, with generally mild summers and cool winters with the occasional heavy frost.

Noel and Marie run around 120 beef cattle (mixed breeds) and 500–600 Merino sheep with first-cross lambs. Lambs are sold at livestock auctions at Cooma or Wagga Wagga, or sold privately. Wool is marketed through a broker.



John Virtue

View of Glenayr.

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The problem

Fireweed has been in the Bega Valley since at least 1968 and is now widespread in the region. Drought years, when winter pastures are sparser, have led to significant increases in fireweed coverage.

Fireweed was first found on Glenayr in 1978 and is now found broadly across the property. Noel has been highly active in the Bega Valley Fireweed Association, which has been successful in raising state and national awareness of the threat of fireweed to the district, leading to investment in biological control research.

For many years, hand pulling was the main control method used for fireweed; however, concerns about personal health impacts and the sheer number of plants to tackle meant other approaches were needed. Spot spraying was attempted, but fireweed became so common that Noel shifted to boom spraying with bromoxynil herbicide. This in turn became too expensive – in the 1990s Noel spent around $33,000 over three years using bromoxynil. He was also constrained by needing to apply it at 16°C or lower so that clovers were not 'burned'. A more sustainable way was required to control fireweed across the property so that beef cattle could continue to be run.

John Virtue

A flock of sheep grazing kikuyu pasture.

John Virtue

Noel at the sheep yards.

The approach

Fireweed is now managed successfully on Glenayr using an integrated weed management approach that combines maintaining year-round competitive pastures with judicious use of sheep grazing.

Merino sheep enterprise

Noel and Marie introduced sheep to the property around 12 years ago. Historically, there was sheep farming in the Bega Valley, and sheep have been reintroduced on various properties over the past

15 years as a means of controlling fireweed. Noel estimates there are now 8–10 farmers running commercial sheep enterprises.

Merino sheep were chosen because they enable a dual enterprise of wool production and first-cross lambs (with Border Leicester rams). Merinos are also easier to contain than some meat breeds, such as Dorpers. However, the cattle fences needed to be upgraded for sheep by adding ringlock mesh. Sheep yards and a shearing shed were also needed, and Noel built a two-stand shearing shed as an extension to an old dairy. Lambing happens in September, and shearing is performed about four weeks prior to this.

The sheep are run as six different flocks across the property. Continuous rotational grazing occurs between 32 paddocks. Paddock grazing and rest times vary according to paddock size, time of year and seasonal conditions. The sheep graze the fireweed among the other pasture, particularly favouring it when in flower. There is no fixed order regarding whether the sheep go into a paddock before, at the same time as or after the cattle (which do not graze the fireweed).

Sheep health and welfare is important, and the Merino breed is particularly prone to worms and flystrike. Worm treatments occur monthly for six months over the warm season, especially to prevent barber's pole worm. Worm drenches are rotated between different active ingredients to reduce the risk of developing resistance. Risk of warm season flystrike is reduced by applying CLiK™ Extra Spray-On in October, while still monitoring flocks regularly for any affected individuals. Monitoring is also conducted for foot abscesses. Fox baiting is carried out in collaboration with three neighbours in August, prior to lambing.

Maintaining perennial pasture

The perennial grass pastures consist of kikuyu, cocksfoot and phalaris. This mix provides both warm and cool season growth, leading to competitive pasture throughout the year. Various clovers provide a legume component.

Winter-growing pastures are regenerated in various paddocks every 10–15 years to maintain their density and productivity. Noel's approach is to sow in autumn following the steps below:

Early January	'Full rate' of glyphosate herbicide (4.8 L/ha of 450 g/L glyphosate product) is boom sprayed to kill the kikuyu and other weeds.
Late January	Paddock is burned to remove biomass for easier sowing.
Late February – Early March	A lower rate of glyphosate (2 L/ha of 450 g/L product) is boom sprayed to control germinating weeds, including fireweed.
Late February – March	Sod seeding (direct drill) is performed using a Duncan Renovator, sowing a mix of cocksfoot, phalaris, white clover, red clover (*Trifolium arvense*), ryegrass and fescue. This can be done as early as the day after the second glyphosate application if soil moisture conditions are suitable for sowing.
March	200 kg/ha fertiliser (single super containing P, S and calcium (Ca) or a mix also containing K) is applied with a spreader, either following the second herbicide treatment or after sowing.
April – May	6–8 weeks after sowing, sheep are let into the paddock for 1–2 days to clean-up fireweed seedlings, which are higher than the germinating grasses at this stage.

The use of glyphosate described above stops the dominance of kikuyu, but it re-establishes from seed and rhizomes over time. In spring to early summer, kikuyu pastures may be slashed hard (to around 5 cm high) to rejuvenate growth and to keep it at a shorter height for the sheep. Paddocks receive around 100 kg/ha of fertiliser in autumn every few years, depending on nutrient requirements and fertiliser prices.

John Virtue

John Virtue

Fireweed emerging in resown winter pasture, May 2022.

Lessons learned

While the primary motivation for introducing sheep to the property was to aid fireweed control, Noel and Marie have found that running Merino sheep for wool and prime lambs is a profitable enterprise on the Far South Coast of NSW.

The sheep have integrated well with their cattle, and the couple have avoided the high cost of herbicide spraying for fireweed. Bromoxynil has not been applied for over 10 years. Noel's advice is to do what you can according to finances and capabilities.

Future challenges

While Noel and Marie have devised a management approach that suits their needs and property, a high density of fireweed seedlings continues to emerge annually in their paddocks. The hope is that fireweed biological control research will result in an agent that will deliver long-term suppression of seed set.

African lovegrass is now a major pasture weed concern on the property – the sheep do not like eating it. Noel regularly searches for outbreaks of lovegrass, driving his all-terrain vehicle in lines 20 m apart and spot spraying with flupropanate herbicide.

4.3 Combining beef cattle, sheep and goats, Quaama

Fireweed management objective: *Manage impacts*

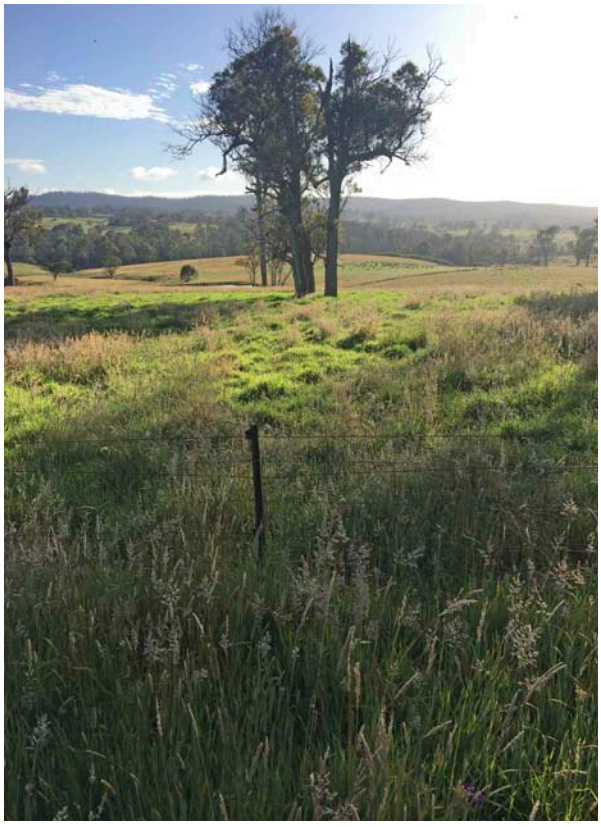
- ☑ *conservative stocking rate*
- ☑ *rotational grazing*
- ☑ *sheep and goats eat fireweed*

Key points

- **A mixed livestock enterprise combining beef cattle, sheep and goats has resulted in minimal impacts of fireweed on farm profitability.**
- **Groundcover is maintained through a conservative stocking rate and regular paddock rotation.**
- **When taking on sheep or goats, aim to keep costs down and research market opportunities.**

The property

Peter and Shelli Muirhead run around 40 Square Meater beef cattle, 200 Merino sheep, 200 cross-bred meat sheep (Poll Dorset/Suffolk/Southdown) and 200 cashmere goats on an 80 ha grazing property in Quaama, about 30 km north of Bega. The property has a mix of irrigated kikuyu and native grass pastures.



Peter Muirhead

View of the Quaama property.

Chapter 4

The problem

Peter and Shelli bought the property in 2007, and fireweed was already prevalent across the property. The kikuyu pasture is productive over summer but dies off from July to September, enabling fireweed to establish. Fireweed needed controlling to ensure the pastures were suitable for grazing by beef cattle; however, Peter and Shelli did not want to rely on herbicides. They expanded their livestock enterprises to include sheep and goats for both fireweed suppression and income diversity.

The approach

Fireweed is managed on the property through the use of sheep and goats, combined with a conservative stocking rate and rotational grazing to maintain groundcover. The property has 40 paddocks, enabling regular stock rotation and sufficient rest periods for pasture recovery. Grazing pressure on the kikuyu is reduced over winter. Lambing, kidding and calving occurs in spring, and these are generally sold in late autumn. Off-loading stock before the winter feed gap reduces the expense of supplementary feeding (e.g. purchasing sheep nuts). Clover regenerates naturally, assisting in maintaining soil N levels for grass growth.

While the fireweed problem has worsened in the district, Peter now observes only occasional plants in the couple's paddocks. With the use of goats and sheep, Peter and Shelli do not need to spend money on herbicides for fireweed control.

Peter advises that sheep and goats require more work than cattle – there are more individual animals to tend per hectare, and goat and sheep health can be challenging in the humid coastal environment. Goats are particularly susceptible to worms and foot abscesses.

The worm burden in stock is reduced by drenching (four times per year) before stock move into a new paddock, plus having cattle graze first in a paddock to reduce the barber's pole worm burden. Shearing in July–August helps reduce flystrike issues and applying CLiK™ in January/February also helps.

Fencing has had to change from barbed wire cattle fencing to hinged joint netting (7/90/30 specifications) to contain the goats and sheep as well as cattle. A single hot wire (i.e. electrified wire) is also used, with a line of barbed wire at the top.

Peter Muirhead

Square Meater beef cattle, Southdown sheep and cashmere goats.

Lessons learned

Peter's mantra is to maintain groundcover using rotation and conservative stocking rates to avoid overgrazing. He and Shelli have been able to maintain good groundcover even during prolonged drought.

Peter Muirhead

Conservative stocking and frequent rotation enables year-round groundcover.

Despite their more intensive husbandry, the sheep and goats have been valuable in helping to control fireweed. Having the diverse stock enterprises of meat sheep, wool, cashmere and beef enables access to a range of markets to spread income sources.

Keeping costs down and researching markets reduces financial risk when moving into a new enterprise. For example, the single stand shearing shed was a $5000 extension to an existing building.

Peter Muirhead

Peter Muirhead

The one-stand shearing area built within an existing shed.

Meat sheep are profitably transported to the Wagga Wagga markets. Cashmere fibre is sold in bulk through collective sale with other goat producers, and goats are sold for meat though Auctions Plus.

Future challenges

Peter plans to explore pasture renovation with winter-growing species as a way to help address the winter feed gap from the kikuyu pasture and the associated costs of supplementary feeding. This will also provide competition with any emerging fireweed.

4.4 Building resilient beef cattle pastures, Dorrigo

Fireweed management objective: *Contain and reduce*

- ☑ *competitive pasture year-round*
- ☑ *strategic grazing*
- ☑ *constant removal of isolated fireweed plants*

Key points

- **The property is a beef cattle enterprise where fireweed infestations were initially managed through frequent, intensive hand pulling.**
- **The main focus is now on continual pasture improvement with careful management of stocking rates to maintain competitive ground cover.**
- **Good winter pasture establishment has been achieved by surface sowing a diverse seed mix, which is then covered by mulched pasture.**

The property

Rowley and Clare Beckett bought 96 ha south of Dorrigo township in 2001, moving to the property to live in 2004. Their grazing property, 'eManzini', is undulating volcanic soil country of around 830 m elevation, receiving an average annual rainfall over the last three years of 2935 mm.

Rowley and Clare run 60 shorthorn beef cows and replacement heifers on kikuyu-dominated pasture, rotating them between 11 paddocks. They are joined to an Angus bull, and calves are sold upon weaning at eight months of age.

John Virtue

A view of eManzini.

The problem

Fireweed arrived on the Dorrigo Plateau in the mid-1990s and is now widespread throughout the district. Rowley and Clare's property was relatively clean at the time of purchase and only a few fireweed plants were evident. Action was needed to address the worsening situation and protect the property's pasture asset into the future.

The approach

Intensive hand pulling

Rowley initially chose to hand pull fireweed in preference to using herbicide. He and Clare are generally averse to using chemicals unless there is no effective alternative solution available. The rationale for hand pulling was that it would avoid contributing to the seed bank as long as plants were removed before seed set, whereas spraying flowering plants risked viable seed remaining.

In the early years, Rowley would sometimes spend five hours a day hand pulling fireweed across the property. He estimates he put in an average of 14–20 days a month for the best part of five years to deal with the fireweed 'plague'. While this manual does not recommend hand pulling for widespread fireweed infestations on large properties owing to its intense and prolonged labour requirements, in this case the huge effort paid off.

During occasional bad fireweed years when the weed was clearly establishing itself, Rowley would boom spray herbicide in addition to hand pulling. He applied 1.5 L/ha Bromicide® 200 (200 g/L bromoxynil) with 1.5 L/ha Amicide® 625 (625 g/L 2,4-D amine) and 500 mL wetting agent in 400 L of water.

In 2022, Rowley found few fireweed plants. He continues to traverse the property systematically in a side-by-side utility vehicle, which enables ready access across all paddocks and easy carrying of bagged fireweed. He always carries a few fertiliser bags for the fireweed, gently tapping the dirt off the roots with a cane knife before bagging plants.

John Virtue

A single fireweed found while paddock searching (note, gloves are usually worn).

All fireweed is placed in a 1 t fertiliser bag back at the shed where it quickly rots down. Periodically, Rowley will jump into a bag to stomp it down. This way, a single bag will accommodate an enormous volume of fireweed, which is easily disposed of using a front-end loader to transport it to a burial pit. Any seeds that remain viable after the decomposition process are contained in the bags, preventing spread during transportation or at the dump site.

John Virtue

John Virtue

Rowley placing fireweed into a large fertiliser bag to rot down.

Pasture improvement and stock rotation

While great gains have been made on the property, fireweed seed continues to blow in from nearby properties. In addition to hand pulling, the property's defences against fireweed invasion have been bolstered by improving the pasture. The kikuyu-based pasture was 'a bit rough' when Rowley and Clare arrived, and they have increased its diversity and productivity.

John Virtue

Cattle grazing winter pasture species among frosted kikuyu, July 2022.

Conservative stocking and frequent rotation of the 55–60 cow herd is vital to maintain pasture cover. Rowley seeks to maintain a stocking density of around 1.4 breeding cows/ha (not including heifers and calves). The approach is to limit stock numbers to what can reasonably be expected to carry through winter without having to conserve fodder or source feed externally. Cattle are in a paddock for an average of four to five days, and the paddock is given a subsequent rest period of around six weeks before the next grazing.

Kikuyu's productivity must be maintained. In summer, when the kikuyu was too thick, Rowley used to slash it to about 15 cm high following grazing of a pasture. These days, he uses a Müthing mulcher (also called a flail mower) in December–January to reinvigorate the pasture, cutting it down to a height of 2.5–5 cm.

The mulching across the soil surface helps to build soil carbon for better soil health and also allows sunlight to penetrate, thereby enhancing the lateral spread of grasses as well as seed propagation. Note that any fireweed present is hand removed before mulching so that there is no risk of seed spread or risk to cattle from grazing fragments.

Winter-growing pasture species have been introduced. In late summer, a pasture mix of ryegrass (annual, perennial and hybrid varieties), cocksfoot and clovers (red and white) is sown. The seed is broadcast using an Iris electric spreader mounted in front of the tractor, with the mulcher at the rear simultaneously providing a thin layer of mulch to cover seed for germination. Establishment levels have been very good with the surface sowing and mulching approach. Rowley also makes use of a sod seeder for more precise placement of smaller seeded pasture species, as circumstances permit.

Rowley Beckett

Seed is broadcast with a spreader (lowered for application) and immediately covered by mulch.

Paddocks are fertilised and limed as needed, based on soil test results. Single super ('straight super') fertiliser is applied annually at 175 kg/ha, containing P, S and Ca. N is applied using urea fertiliser at 40 kg/ha in June to aid the establishment and early growth of the sown pasture grasses. Approximately 2.4 tonne/ha of fine lime is broadcast across one-third of the property each year.

Lessons learned

In Rowley and Clare's case, hand pulling has paid off in terms of managing the fireweed problem and keeping it in a maintenance phase, albeit after many years of intensive and time-consuming physical labour. The improved pastures and management of grazing intensity help to maintain competitiveness against fireweed invasion, reducing its establishment and thus the amount of hand pulling required. Use of the mulcher has led to a quantum improvement in pasture yield and a marked reduction in weeds.

Rowley Beckett

Rowley Beckett

Mulching pasture in January 2023 and regrowth two weeks later.

Rowley recommends also focusing on other weed threats. Giant Parramatta grass is another priority pasture weed, and Rowley wishes he had paid this weed more attention at the early stages of pasture invasion. The nation-wide shortage of flupropanate herbicide in 2022 made management of this weed even more difficult. The planning chapter (Chapter 3) stresses the importance of identifying all priority weeds and designing a holistic management approach from the start.

Future challenges

In Dorrigo, 2022 was an extremely wet year. Much of the farm became pockmarked from cattle pugging the soil, increasing soil disturbance and bare patches. This created ideal conditions for fireweed emergence. It has also made walking difficult, increasing safety risks when undertaking routine paddock duties. With potential for more frequent swings between La Niña and El Niño weather patterns in the future, weed and pasture management will need to be flexible.

4.5 A beef cattle lifestyle property, Dorrigo

Fireweed management objective: *Manage impacts*

- ☑ *tactical herbicide use*
- ☑ *competitive pasture year-round*
- ☑ *rotational strip grazing*

Key points

- **A beef cattle lifestyle property where fireweed is being suppressed through pasture cover and herbicides.**
- **Warm and cool season pasture species are grown, with rotational grazing, including intensive strip grazing.**
- **Boom spraying of fireweed is done in autumn and spot spraying at other times.**

The property

Pam and Colin Cork run 50 breeders of Angus and Murray Grey cattle on 70 ha west of Dorrigo. A family farm since 1899, Pam and Colin have lived there for 45 years.

The small lifestyle property is hilly, ranging from 750–900 m altitude, with kikuyu-dominated pasture on red basalt soil. Annual rainfall is around 1700 mm, although in 2022 it was around 3400 mm, albeit with a dry spring. Approximately 40 ha of the property is kikuyu pasture. The remaining lower 30 ha is mainly remnant rainforest and wet sclerophyll forest.

Pam Cork

Cows grazing in frosted kikuyu pasture.

Chapter 4

The problem

Fireweed was first detected on Pam and Colin's property in the 1990s and quickly became entrenched in the district. While they battled to eliminate it for many years, they found that it quickly reinvades, blowing in from nearby properties and germinating from the existing soil seed bank. Fireweed establishment is worse on high, rocky slopes that are hard to access and have less dense pastures.

Pam and Colin have needed to learn to live with fireweed. While the weed is here to stay, they know it can be controlled so that it does not significantly affect their beef cattle enterprise.

John Virtue

John Virtue

Steep hillsides on the property are more prone to fireweed invasion, July 2022.

The approach

Pam and Colin take a multipronged approach of herbicidal control and pasture management to maintain fireweed density at low levels.

Pasture management

Colin says it is important to let the pasture grow tall to suppress fireweed – 100% groundcover is needed. The kikuyu pasture also contains paspalum, ryegrass, cocksfoot and clovers, giving growth year-round. Adequate nutrition is important – Colin tends to see more fireweed on the lower fertility soils where there is less competition from pasture.

The grazed part of the property has six 'good' paddocks, which in turn are split by portable electric fencing to enable strip grazing in late winter–spring. This gives flexibility to decide which parts of paddocks are grazed and for how long. Narrow strips are intensively grazed for a couple of hours to ensure a high level of feed utilisation and then rested until the next rotation. The grass grows well under intensive strip grazing, with little fireweed present. There are also smaller paddocks on steep hills which are less intensively grazed and more prone to fireweed.

Pam Cork

Strip grazing behind portable electric fencing.

The cattle are normally in one herd but are split when cows are separated for mating in September–October. Stocking rate varies but is commonly around 1.1 cow + calf units per hectare (averaged over the improved pasture portion of the property).

To sow winter feed, a paddock is grazed down in autumn, followed by slashing. A complete fertiliser (containing N, P, K and S) is applied at about 300 kg/ha, 1–2 weeks before sowing. Another fertiliser application is done in spring. A mixture of annual and perennial ryegrass and white clover are sown either using a sod seeder or broadcast with a spreader. Plantain (*Plantago lanceolata*), chicory and leafy turnips (*Brassica* sp.) are sometimes included as additional forage species – these provide greater pasture diversity and productivity but are susceptible to herbicides used to control broadleaf weeds such as thistles and fireweed.

Liming is important for pasture growth, which in turn builds organic matter. A 'tonne to the acre' (2.4 t/ha) of lime is applied every 3–4 years. Superphosphate fertiliser is also broadcast over the entire property every 3–4 years.

Spraying fireweed

Bromoxynil is applied in March–April at 1.5 L/ha, using a 600 L boom spray with 6 m wide boom. Sometimes, bromoxynil is mixed with 2,4-D amine, which provides a higher kill rate for fireweed and is also effective on other broadleaf weeds. Fireweed germinates any time of year in Dorrigo, so plants may be at all stages of growth.

Colin attempts to spray half the farm for fireweed at once. The cattle are kept on the non-sprayed area for the duration of the eight-week bromoxynil grazing withholding period. This can create feed challenges on a small farm, especially in poorer seasons.

Hand-held spot spraying of larger fireweed plants is performed anytime, using Grazon® Extra (aminopyralid + picloram + triclopyr) at 350 mL per 100 L water. A 100 L spray tank is mounted on the side-by-side utility vehicle. This includes areas where it is too rough or steep to boom spray, or in seasons when it is too wet to access paddocks with the tractor.

Pam Cork

Spot spraying of mature fireweed.

Pam and Colin hand pulled fireweed from 1995 to 2018. Bagged fireweed was left to dry in the shed and then emptied into steel drums for burning. This method, while time consuming, was highly effective. However, it was discontinued for health and safety reasons. Health and safety risks associated with hand removal may include repetitive strain injuries and traversing cattle-pugged ground. Gloves need to be worn to avoid skin contact with fireweed.

Lessons learned

Thick grass pastures suppress fireweed. There is a fine line between pasture utilisation for profitability and not overgrazing, which increases the risk of fireweed. Overall, this requires effective pasture management.

Future challenges

The extreme rainfall of 2021–2022 impeded paddock access to carry out fireweed control. Cattle pugging of the wet soil and associated destruction of ground cover was likely to promote fireweed emergence.

Fireweed is continuing to spread through the Dorrigo Plateau and starting to appear more frequently on the higher elevation country to the west towards Armidale. Winter temperatures do not appear to be a major constraint. Pam and Colin's property receives moderate frosts, with minimum temperatures down to −5 °C. While this causes the kikuyu to die back, it does not kill the fireweed.

John Virtue

Disturbed soil after cattle grazing opens up ground for fireweed.

Pam notes there are also other important weeds to manage. For example, in the forested area on the property there is a new environmental weed called mahonia (*Berberis lomariifolia*), a prickly ornamental plant with bird-dispersed seeds that readily germinate.

4.6 A lifestyle property running sheep, Mystery Bay

Fireweed management objective: *Contain and reduce*

- ☑ *rotational grazing of sheep*
- ☑ *frequent mowing of amenity areas*
- ☑ *constant removal of isolated fireweed plants*

Key points

- **A coastal lifestyle property that was prone to fireweed invasion.**
- **Fireweed is kept under control by grazing Dorper sheep.**
- **Frequent lawn mowing suppresses fireweed around property buildings and roads.**

The property

Mark and Teresa Stubbings moved from Sydney to a 40 ha property in Mystery Bay in 2018. Located between Tilba Tilba Lake and the Eurobodalla National Park, the coastal lifestyle property consists of around 28 ha of cleared pasture, 8 ha of forest and 4 ha of saltmarsh. The local climate is temperate, with generally mild summers and cool winters and an average annual rainfall of approximately 900 mm. The clay soils can become saturated during prolonged wet weather.

Mark Stubbings

View over the grazing paddocks.

Chapter 4

Mark and Teresa enjoy the rural lifestyle, the serenity of the property and the strength of the local community. Mark is President of Tilba Environment Landcarers (TEL), which has around 35 members. TEL organises local landcare and bushcare projects, runs education forums and advocates for protecting the local environment. TEL's scope includes controlling or eradicating threatening weeds in the district.

The problem

Fireweed has been in the Tilba district for several decades, and Mark and Teresa's property is prone to seed blowing in on northerly breezes. When they first arrived, fireweed was quite thick in areas where soil had been disturbed to build access roads, and of moderate intensity in the open paddock areas.

Given the pristine nature of the local environment, Mark and Teresa sought to keep their property in good condition – this included a desire to keep fireweed at minimal levels. In turn, they were contributing as local land managers to keeping fireweed at bay in the district.

The approach

Mark and Teresa's initial approach to fireweed was hand pulling. They would do half-days for one week per month. They had a large hole dug by an excavator and tossed in 'bags and bags' of fireweed to rot down.

Mark and Teresa introduced livestock to utilise the cleared areas of the property. Using ringlock fencing, they made two large grazing paddocks, excluding the saltmarsh and the forested areas adjacent to the national park. The paddocks consisted mainly of kikuyu and tussock grass (*Poa labillardierei*) and were more prone to fireweed invasion than the other areas.

Mark Stubbings

Bagged fireweed rots down over time.

Dorper sheep were chosen because they had a local reputation for removing fireweed and they did not require shearing, being a self-shedding meat breed. They are observed to readily graze the fireweed down, and Mark estimates there is now less than 1% fireweed in the paddocks.

The sheep are run in two flocks – ewes and lambs in one paddock and rams and wethers in the other. Each paddock is further split into three 'sub-paddocks' using portable electric fencing. Flocks are moved every three weeks, enabling each sub-paddock to be rested for at least six weeks. Two beef

Mark Stubbings

Dorper wethers.

steers follow after a flock, where any fireweed has already been grazed out. Then, the sub-paddock is slashed to rejuvenate the kikuyu and obtain even regrowth.

Mark Stubbings

The two steers behind ringlock and portable electric fencing.

In November 2022, Mark and Teresa had 30 ewes (with lambs), but they are planning to reduce numbers to a more sustainable flock size of around 20 ewes. Ewes are joined in May for a September–October lambing. Lambs are sold off in autumn, using the services of a stock agent, before kikuyu growth slows in winter.

The sheep are observed daily to detect any health problems. The Dorpers have proven to be robust, with just some foot abscess issues when the pastures are wet for long periods. Barber's pole worm needs to be managed, and the sheep are regularly drenched for internal parasites, following a set program. To date, the sheep have not experienced any flystrike issues.

Areas around the house, sheds and driveway are mown every 10–14 days from spring to summer to suppress fireweed. When isolated fireweed is found in other areas, it is hand pulled and bagged – Mark and Teresa now fill only two bags a month. Wallabies have also been observed to eat fireweed down to the ground.

Ellen Stubbings

Teresa and Mark – frequent mowing controls fireweed around the house.

Lessons learned

Being relatively new to the district and to a rural property, they are definitely still learning. Mark says it is important to talk to 'older heads' and build a local network. The Dorpers fit well with Mark and Teresa's current lifestyle because they are relatively low maintenance and 'pay for themselves'. Herbicides have not been required to control fireweed – its presence is now only occasional in the pastures, where it is promptly eaten.

While the Dorpers work well, Mark and Teresa nonetheless experience a constant time commitment of having stock to manage, which limits their ability to go away for extended periods. A future option could be agistment of someone else's sheep at certain times of year, to still utilise the pasture and keep fireweed at minimal levels.

Future challenges

Mark and Teresa are maintaining a relatively low input livestock enterprise on their lifestyle property. They have not yet applied fertiliser to the pastures and do not sow cool season pastures. They are wary of carrying too many sheep in winter when kikuyu growth is slow. A good level of clovers in the pasture provides some N for grass growth. However, over time they know they will need to explore options for maintaining pasture productivity.

4.7 Regional suppression of fireweed, Far North Qld

Fireweed management objective: *Contain and reduce*

- ☑ *regular surveillance for fireweed*
- ☑ *constant removal of isolated fireweed plants*
- ☑ *legal requirements to report and control*

Key points

- **The higher altitudes of the Southern Atherton Tablelands provide suitable habitat for fireweed, over 1000 km north of its main distribution in Australia.**
- **Searching for and mapping fireweed, and developing a management plan, is essential if pursuing a containment strategy.**
- **Eradication of fireweed has proven difficult owing to frequent flowering, ease of spread and changes and challenges in management agencies.**

The region

The Atherton Tablelands in Far North Qld (FNQ) is a coastal mountain plateau, with elevation of 400–1000 m. The area has rich, volcanic soils and supports diverse agricultural industries, including dairy, beef and a broad range of horticultural crops. Despite being in the tropics, its high altitude produces a warm-temperate climate with relatively cool winters and summers. Annual rainfall is in the range of 1500–2500 mm across the tablelands.

The problem

An incursion of fireweed was discovered at Millaa Millaa in the southern Atherton Tablelands in 2008. This was over 1000 km north of the main infestations of fireweed in south-eastern Qld. It was thought to have been introduced as a contaminant carried on roadside management machinery. Because the Atherton Tablelands and surrounds have climatic similarities to south-eastern Qld, where fireweed is widespread, the weed is a significant threat to dairies and cattle grazing in the area.

In 2022, fireweed was still extremely limited in its regional extent. This can largely be attributed to its early detection and sustained efforts to contain and eradicate it.

Infestations of fireweed are known to be present at three main localities: East Evelyn (Millaa Millaa), Wondecla and Wongabel. Intensive searching on roadsides and private properties at these sites located 1233 plants in 2022. Individual or scattered plants have been found elsewhere, including north-east of Malanda, south of Millstream and west of Mareeba.

Tablelands Regional Council

Tablelands Regional Council

Tablelands Regional Council

Detections over the 2020–2022 period of individual fireweed plants in FNQ at East Evelyn (top), Wondecla (middle) and Wongabel (bottom).

Intensive regional control program

Travis Sydes, Regional Natural Asset Management and Sustainability Coordinator of the FNQ Regional Organisation of Councils, says that preventing fireweed becoming widely established in FNQ remains a regional priority. The weed remains extremely geographically restricted.

Tablelands Regional Council (TRC), the local weed control authority, has invested substantially in suppressing fireweed. A regional fireweed management plan was developed in 2016, and fireweed is one of 20 priority pest plants listed in the *Tablelands Biosecurity Plan 2019–2024*.

TRC staff Tudor Tanase, Manager Environment and Natural Resources, and Tehiva Hands, Acting Senior Land Protection Officer, currently oversee an intensive control program that aims to remove outlier infestations and reduce the extent and density of core infestations.

Tablelands Regional Council

Field searching for fireweed plants.

All known infestations are searched by TRC staff every three to four weeks to detect, map and hand remove new plants. The work effort equates to four TRC staff spending three days each month searching. Search areas are GPS recorded using a phone app. The search area includes a 1 km buffer around each infestation.

Tablelands Regional Council

Fireweed searching at East Evelyn, August 2020.

Tablelands Regional Council

Recording both presence and absence locations of fireweed.

The intent is to detect and remove plants before they set seed. Failing that, seeding plants are carefully bagged. Grazon® Extra spot spraying has also been used in instances when too many plants hindered thorough and timely hand removal.

Where fireweed is present on a property, TRC assists owners to develop a property biosecurity plan. Such plans include not moving soil or plant material from an infestation area and controlling all known plants.

Under Qld's *Biosecurity Act 2014*, fireweed is a restricted matter. It is illegal to move, share, give away or sell the plant. Everyone is required to take all reasonable and practical steps to minimise the risks associated with invasive plants under their control, as per the Act's general biosecurity obligation. Under the *Tablelands Biosecurity Plan*, infestations must be reported.

In 2019, TRC received Australian Government funding to undertake additional surveillance using a detector dog and citizen science volunteers. The dog readily located non-flowering plants. Over 1100 ha was searched, resulting in minor increases in the known infestation area. Public education and awareness was expanded through media articles and YouTube videos.

Tablelands Regional Council

Using a sniffer dog to detect fireweed seedlings.

Lessons learned

Eradication of fireweed is difficult at the property scale and even more so at the regional scale. It requires a high staff resource commitment to conduct regular surveys, plus the cooperation of landholders to report new outbreaks. A further complication is that fireweed grows and flowers at any time of year in the Atherton Tablelands.

Nonetheless, Travis believes at least localised eradication is possible if a new infestation of fireweed is caught early. Moreover, there is still regional economic value in continuing to suppress some of the larger infestation sites to reduce the risk of further spread.

Future challenges

An update to the 2016 TRC fireweed management plan is needed to take account of more recent detections of the weed. Sites must be prioritised for their relative risk of further spread, to work most effectively within the confines of available resources. Regarding the core infestations, the right balance must be struck between landholder-led and TRC work.

Ongoing education and awareness will be fundamental to keeping fireweed contained. Movement of livestock, machinery and vehicles from infested to uninfested areas remains an ongoing risk in preventing regional spread. Property biosecurity practices, such as washdowns and quarantining stock, are important.

The biggest challenge to success with fireweed is that it is one of many new and emerging weeds threatening the Atherton Tablelands. Other new invaders include Crofton weed (*Ageratina adenophora*), stevia (*Stevia ovata*) and white ball acacia (*Acaciella angustissima*). Managing multiple, high-priority biosecurity programs requires sustained commitment, resourcing and community support – big expectations for a small regional council.

Chapter 5

Further information

5.1 Fireweed legal status and responsibilities in Australia

Table 5.1 briefly describes what legal provisions relate to fireweed in each state and territory and at the national level.

Table 5.1 Declaration status of fireweed in jurisdictions (current as of May 2023).

Jurisdiction	Legislation	Declaration	Description
Australia	*Biosecurity Act 2015*	Not permitted	Not permitted for entry into Australia.
Australian Capital Territory	*Pest Plants and Animals Act 2005*	Declared	Notifiable. Must be suppressed (i.e. all infestations on a premises must be controlled). Prohibited (i.e. supply and propagation is not allowed). This includes the importation of fireweed plants, seeds or materials contaminated with plants or seeds into the ACT. Turf cannot be imported from turf farms in NSW where fireweed is known to occur (ACT Government, 2014).
New South Wales	*Biosecurity Act 2015*	Declared	Must not be imported into the state, sold, bartered, exchanged or offered for sale. General biosecurity duty to ensure a biosecurity risk is prevented, eliminated or minimised, so far as is reasonably practicable. Regional strategic weed management priority in certain parts of the state (refer to NSW DPI website for current regions).
Northern Territory	*Weeds Management Act 2001*	Declared	Not to be introduced to the Northern Territory (Class C).
Queensland	*Biosecurity Act 2014*	Declared	Category 3 restricted invasive plant. Illegal to give away, sell or release into the environment. General biosecurity obligation to take all reasonable and practical measures to minimise the biosecurity risks associated with dealing with fireweed. Contact local councils for any additional control requirements.
South Australia	*Landscape South Australia Act 2019*	Declared	Prohibited entry to South Australia. Cannot be moved or sold as a plant or contaminant. Land owners to control the plant on their properties. Recovery of control costs on adjoining road reserves.
Tasmania	*Biosecurity Act 2019* (Note the *Weed Management Act 1999* is expected to be repealed in 2023)	Declared	The importation, sale and distribution of fireweed are prohibited in Tasmania.
Victoria	*Catchment and Land Protection Act 1994*	Declared	Restricted weed in whole of the state. Trade in fireweed and its propagules (either as plants, seeds or contaminants in other materials) is prohibited.
Western Australia	*Biosecurity and Agriculture Management Act 2007*	Not declared	Prohibited organism to be excluded from WA.

5.2 Sources of pasture management information, decision tools and training

The following tables provide web links to sources of further information, decision tools and training for pasture management.

Table 5.2 Sources of online information on pasture establishment and management.

Business Queensland	www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/grazing-pasture
Dairy Australia	www.dairyaustralia.com.au Follow the **Feed & Nutrition > Growing Feed for the Herd** links for information on growing and grazing dairy pastures.
FutureBeef	futurebeef.com.au/
NSW Local Land Services	www.lls.nsw.gov.au/
Meat & Livestock Australia (MLA)	www.mla.com.au/ **MLA's persistent pastures hub** provides information on a wide range of pasture types found across southern Australia. www.mla.com.au/extension-training-and-tools/feedbase-hub/persistent-pastures/
NSW Department of Primary Industries	www.dpi.nsw.gov.au/agriculture/pastures-and-rangelands This includes the checklist of **Eight steps for achieving successful perennial pasture establishment**, which are also broadly applicable to renovating existing pastures. www.dpi.nsw.gov.au/agriculture/pastures-and-rangelands/establishment-mgmt/establishment/eight-steps
Pasture management for South East Queensland	futurebeef.com.au/wp-content/uploads/SEQ-pasture-sml.pdf A detailed guide on species suitable for production pastures in this region.

Table 5.3 Online tools to assist with pasture management decision-making.

Australian Wool Innovation 'Feed On Offer'	www.wool.com/land/pastures/feed-on-offer
Future Beef	futurebeef.com.au/land_management/decision-support-tools/
Meat & Livestock Australia (MLA) tools and calculators	etools.mla.com.au/hub/
MLA 'More Beef from Pastures' online manual	mbfp.mla.com.au/
Pastures Australia 'Pasture Selection Tool'	keys.lucidcentral.org/keys/v3/pastures/
Stocktake GLM decision support app	stocktakeglm.com.au/

Table 5.4 Example sources of training in pasture management (May 2023).

ACS Distance Education 'Pasture Management'	www.acs.edu.au/courses/pasture-management-180.aspx
Meat & Livestock Australia (MLA) 'Grazing land management EDGE'	www.mla.com.au/extension-training-and-tools/edgenetwork
MLA Healthy Soils & Pastures training package	elearning.mla.com.au/courses/?filter-categories=healthy-soils-pastures
NSW Department of Primary Industries 'PROGRAZE'	www.dpi.nsw.gov.au/agriculture/pastures-and-rangelands/establishment-mgmt/grazing-management2/prograze-profitable,-sustainable-grazing
Pinion Advisory 'Pasture Principles'	www.pinionadvisory.com/training-workshops
RCS 'Grazing for Profit School'	www.rcsaustralia.com.au/products/family-business/grazing-for-profit-2
Tocal College 'Introduction to pastures'	www.tocal.nsw.edu.au/courses/short-courses/weeds/introduction-to-pastures

5.3 Competitive pasture species observed to suppress fireweed germination and growth

Key information sources: Allan et al. (2005), Sindel et al. (2012), Sindel and Coleman (2012) and Wijayabandara (2021). Additional information sources for particular species are given below.

The following table lists pasture species that have been observed to be competitive against fireweed.

Table 5.5 Pasture species observed to suppress fireweed germination and growth.

Pasture species	Description
Cocksfoot *Dactylis glomerata*	▪ Cool season, perennial tussock grass ▪ Grows mainly in autumn and spring, with less growth over winter ▪ Requires at least 450 mm annual rainfall per year in southern, cool temperate zone and 550 mm in northern temperate ▪ Varieties differ in levels of summer dormancy and hence moisture requirements for persistence and growth ▪ Suited to low fertility soils and tolerates soil acidity (Hackney and Dear, 2007)
Kikuyu *Cenchrus clandestinus*	▪ Warm season, perennial grass with prostrate growth ▪ Most growth in spring, summer and autumn ▪ Spreads via runners (stolons) and rhizomes ▪ Suited to very fertile, well-drained soils in areas receiving at least 800 mm annual rainfall. Good drought tolerance ▪ Poor winter growth. Frost sensitive ▪ Kikuyu-dominated pastures not suitable for horses owing to risk of oxalate poisoning ▪ Can be invasive in horticulture, field crops and native vegetation (NSW DPI, 2004a)
Paspalum *Paspalum dilatatum*	▪ Warm season perennial grass with upright, tufted growth to 1 m ▪ Suited to wetter sites in coastal and inland areas with at least 750 mm annual rainfall ▪ Requires regular slashing/mulching to maintain feed quality ▪ Suited to heavy, fertile soils ▪ Moderate frost tolerance ▪ Invades ryegrass and clover pastures (NSW DPI, 2022c)
Phalaris *Phalaris aquatica*	▪ Cool season perennial grass forming dense swards ▪ Suited to higher fertility soils in tablelands areas with at least 550–600 mm annual rainfall ▪ Varieties differ in their levels of winter and summer dormancy ▪ Highly persistent and drought tolerant ▪ Tolerates wet soils ▪ Not suitable for highly acidic soils ▪ Potential to cause phalaris poisoning in livestock (NSW DPI, 2017)

Rhodes grass *Chloris gayana*	▪ Warm season, perennial grass with upright, tufted growth ▪ Most growth in spring, summer and autumn ▪ Spreads via runners ▪ Grows on a wide range of soils from light sandy loams to well-drained clays ▪ Suited to areas of at least 500 mm annual, summer-dominant rainfall ▪ Moderate resistance to drought and frost. Poor tolerance of waterlogging ▪ Low oxalate levels render it suitable for horses (NSW DPI, 2004b)
Ryegrasses *Lolium* spp. and hybrids	▪ Cool season grasses of short, upright growth from autumn to spring ▪ Annual, biennial, short-rotation and perennial varieties for fertile soils ▪ Longer-lived varieties require cooler summers with adequate soil moisture (or irrigation) to persist. Perennial ryegrass requires a minimum average annual rainfall of 700–900 mm, depending on summer temperatures ▪ Annual and biennial varieties have faster winter growth rates making them highly competitive with fireweed ▪ Autumn sowing from seed should consider herbicide use, to suppress germinating fireweed and other weeds ▪ Tolerant of acid soils, waterlogging and repeat grazing (Dairy Australia, 2020; Launders et al., 2010; Kemp et al., 2004)
Setaria *Setaria sphacelata*	▪ Warm season perennial grass with tall, tussock growth ▪ Most growth in spring, summer and autumn ▪ Suited to warm coastal areas in areas receiving at least 1000 mm annual rainfall ▪ Tolerates acid soils and moderate waterlogging ▪ High oxalate levels make setaria unsuitable for horses (Clarke, 2002)
Tall fescue *Festuca arundinacea*	▪ Perennial, tussock-forming grass with varieties varying in levels of winter and summer growth ▪ Suitable to tablelands and other temperate areas with at least 500 mm annual rainfall for winter-active/summer-dormant varieties, or 750 mm for spring/summer-active varieties ▪ Grows on a wide range of soil types. Tolerates low fertility soils and wet areas ▪ Winter-active varieties will be more directly competitive with fireweed ▪ More frost-tolerant than phalaris and cocksfoot ▪ Slow to establish as seedlings, hence the importance of weed control (including for fireweed) (Harris and Lowien, 2003; NSW DPI, 2022d)
Weeping grass *Microlaena stipoides*	▪ Native, perennial grass with upright growth ▪ Has green growth year-round but most productive from spring to autumn ▪ Adapted to cooler tablelands areas ▪ Suited to a wide range of soils ▪ Tolerant of acid soils, drought and frost (NSW DPI, 2022b)
White clover *Trifolium repens*	▪ Perennial legume that spreads via stolons to form a dense ground cover ▪ Most growth from spring to autumn but can be productive and competitive during winter ▪ Suited to a wide range of soils in areas with at least 750 mm annual rainfall ▪ Needs good summer rainfall or irrigation to persist. Poor heat and drought tolerance ▪ Requires medium to high fertility soils. Tolerates acidic soils ▪ Combines well with many perennial grasses ▪ Can be surface-sown or direct-drilled into existing pasture (NSW DPI, 2022e)

5.4 Registered and permitted herbicides for fireweed

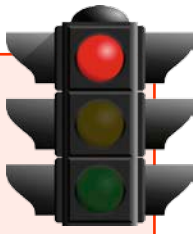
State/territory 'control of use' legislation and off-label use

Pesticide use in Australia varies between states and territories because each jurisdiction has responsibility for developing local regulations on its use. This includes jurisdictional requirements and approvals for off-label use of herbicides, and any restrictions on use or application of particular herbicides. It is your legal responsibility to be aware of and comply with these state/territory requirements, in addition to following the product label instructions.

Off-label use is the use of a herbicide to control a weed that is not covered by an APVMA-approved product label, or by a permit allowing 'persons generally' or specific groups of people to use the herbicide as stated on the permit. Wilful misuse, on the other hand, represents an active or negligent disregard for all instructions and legal requirements with no consideration of the risks.

Table 5.6 summarises current provisions for control of use (off-label use) across states and territories. Table 5.7 provides web links for further information on state or territory pesticide control of use. State/territory contacts for weed control information are given in Section 5.5.

If you are unsure which herbicides may be legally used on a particular weed in your state, contact the weed or biosecurity section of your state or territory department of primary industries or your local weeds officer.



Warning!

Off-label practices DO NOT exclude or override product maximum residue limits, work health and safety or environmental safety.

If intending to use the product off-label, the user must consider the rate of pesticide, time and frequency of application, the likelihood of residues and the potential for worker exposure.

'Off-label use' DOES NOT override Directions for Use 'DO NOT' statements on labels and permits, such as 'DO NOT apply to crops or pastures with clover, lucerne or medics'.

The pesticide manufacturer is not liable for off-label use of their product.

Table 5.8 lists types of herbicides and their registered or permitted uses for fireweed control in Australia in pastures and crops and in other situations, as at September 2022 (APVMA, 2022; Growcom, 2022; NSW DPI, 2019; QDAF, 2022).

Individual herbicide products are not listed since there are >150 registered for use on fireweed, their availability may change over time and new products may enter the market.

To perform a current search on registered herbicide products visit the APVMA website **www.apvma.gov.au** and click on 'Registered chemical products (PubCRIS)'.

Fireweed control minor use permits for some herbicides have been issued for specific situations in individual state and territory jurisdictions. To perform a current search for off-label and minor use permits, visit the APVMA website **www.apvma.gov.au** and click on 'Permits'.

Alternatively, herbicide registrations and permits can be obtained through the INFOPEST Database **www.infopest.com.au**.

In addition to an APVMA search, you should review current herbicide information on the website of the relevant organisation/s of your state or territory government.

Table 5.6 State control of use legislation (off-label) in agricultural chemicals.

Herbicides allowed Yes (Y) / No (N)		ACT	NSW	Qld	WA	SA	NT	Tas	Vic
Rates of application	Lower rate than on label	Y	Y	Y	Y	Y	Y	Y	Y
	Higher rate than on label	N	N	N	N	N	N	N	N
	Lower frequency than on label	Y	Y	Y	Y	Y	Y	Y	Y
	Higher frequency or rate than on label	N	N	N	N	N	N	N	N
Weed	Different weed than on label	Y	Y	Y	Y	Y	Y	Y	Y
Situations and crops	Different crop or situation than on label	N	N	N	N	N	N	N	Y
Application equipment	Different application equipment than on label	N	N	Y	Y	Y	Y	N	Y
Preparation	Tank mixes	Y	Y	Y	Y	Y	Y	Y	Y

For more information: www.awe.gov.au/agriculture-land/farm-food-drought/ag-vet-chemicals/domestic-policy/haccut

Table 5.7 Sources of further information on state/territory pesticide control of use.

Jurisdiction	Web link/s
ACT	www.accesscanberra.act.gov.au/s/article/pest-and-weed-control-tab-Agvet-chemical-use
NSW	www.epa.nsw.gov.au/your-environment/pesticides/pesticides-nsw-overview
Northern Territory	nt.gov.au/industry/agriculture/farm-management/using-chemicals-responsibly
Queensland	www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/land-management/chemical-controls
South Australia	www.pir.sa.gov.au/biosecurity/rural_chemicals
Tasmania	nre.tas.gov.au/agriculture/agvet-chemicals
Victoria	agriculture.vic.gov.au/farm-management/chemicals/offlabel-chemical-use
Western Australia	www.agric.wa.gov.au/biosecurity/pest-and-disease-information-service-padis
	health.wa.gov.au/Articles/U_Z/Using-pesticides-safely

For state and territory department weed control contacts see Section 5.5.

Table 5.8 Herbicides registered or permitted for control of fireweed, October 2022.

Herbicide[a]	State or territory[b]	Registered or permitted situation	Timing	Application[c]	Comments
Bromoxynil (200 g/L) ***Mode of action:*** **Group 6 (= C)**	Various products registered with differing state/territory registrations. Check label to confirm a product is registered for use on fireweed or *Senecio* spp. in your state or territory.	***Pastures:*** Grass, lucerne and clover-based pastures. ***Crops:*** Cereals (wheat, barley, cereal rye, oats, triticale), including those undersown with clover, lucerne or medic (Vic only).	Apply during the autumn–winter period when fireweed plants are young and actively growing. Less effective on mature fireweed plants, which can regrow from the base.	***Boom spray:*** Prior to flower development 1.4 L/ha. Early flowering stage 2.8 L/ha. Use 50–200 L water/ha. Use higher volume (minimum 160 L) where the weed infestation is heavy or pasture cover is dense. ***Spot spray:*** **Handgun:** 75 mL/100 L water. **Knapsack:** 15 mL/100 m^2 per 15 L water. As a contact herbicide, ensure thorough coverage of weeds.	***Withholding period:*** Do not graze or cut for stock food for 8 weeks after application. ***Safety:*** Product is poisonous if inhaled or swallowed. Follow safety directions. ***Contact herbicide:*** Herbicide is not translocated. Older plants may not be killed – reshooting from the base and/or other parts of the plant that received insufficient herbicide exposure. ***Off-target risks:*** Pasture legumes at greater risk if frost damaged, if frosts are imminent, or if maximum temperatures >20°C may follow for some days after application. Certain clovers (e.g. berseem, Persian) and medics (polymorpha types) can be highly sensitive. Consult the product label. ***Other formulations:*** 400 g/L bromoxynil products also registered for fireweed, applied at a lower application rate (refer to label).
Bromoxynil (250 g/L) + diflufenican (25 g/L) ***Mode of action:*** **Groups 6 (= C) & 12 (= F)**	Various products registered with differing state/territory registrations. Check label to confirm a product is registered for use on fireweed or *Senecio* spp. in your state or territory.	***Pastures:*** Newly sown and established clover and/or lucerne-based pastures (but see risks). Including these as cover crops in vineyards. ***Crops:*** Cereals (wheat, barley, cereal rye, oats, triticale), including those undersown with clover and/or lucerne. Including these sown as cover crops in vineyards.	Control of fireweed seedlings up to 4-leaf stage.	***Boom spray:*** 500 mL/ha. Use 70–100 L water/ha. Use higher volume where the weed infestation is heavy or pasture cover is dense. As a contact herbicide, ensure thorough coverage of weeds.	***Withholding period:*** Do not graze or cut for stock food for 8 weeks after application. ***Safety:*** Product is harmful if inhaled or swallowed. Irritant. Follow safety directions. ***Off-target risks:*** Pasture legumes at greater risk if frost has damaged plants, if frosts are imminent, or if maximum temperatures >20°C may follow for some days after application. The tolerance of clover and lucerne varieties can vary with rate of application, soil type, crop health, stage of growth and degree of moisture and temperature stress. Certain clovers (e.g. berseem, Persian, Haifa white, arrowleaf) and medics (polymorpha types) can be highly sensitive. Consult the product label.

Herbicide[a]	State or territory[b]	Registered or permitted situation	Timing	Application[c]	Comments
Bromoxynil (250 g/L) + diflufenican (25 g/L) + MCPA (250 g/L) ***Mode of action:*** **Groups 6 (= C), 12 (= F) & 4 (= I)**	All (some products not WA). One product (Adama Triathlon®) currently registered for fireweed suppression in clover pasture.	***Pastures:*** Newly sown and established clover-based pasture, clover for hay and seed production (but see risks).	Suppression of fireweed seedlings up to 4-leaf stage.	***Boom spray:*** 1 L/ha Good coverage of weeds is essential. Coarse spray droplet size.	***Withholding period:*** Do not graze or cut for stock food for 8 weeks after application. Sprayed weeds may become more palatable to stock, which may result in poisoning. ***Safety:*** Product is harmful if inhaled or swallowed. Irritant. Follow safety directions. ***Off-target risks:*** Pasture legumes at greater risk if frost has damaged plants, if frosts are imminent, or if maximum temperatures >20°C may follow for some days after application. Certain clovers (e.g. rose, strawberry), lucerne and medics can be highly sensitive. Some pasture grasses, including cocksfoot and phalaris, can show initial reduction in growth. Consult the product label. Phenoxy herbicides can cause severe damage to native vegetation and susceptible crops, including grapes, tomatoes, oilseed crops and ornamentals. ***Other formulations:*** Similar products with differing herbicide concentrations available and with addition of picolinafen herbicide.
		Crops: Cereals (wheat, barley, triticale, cereal rye, oats).			
	One product (Stature®) currently registered for turf.	***Other:*** Recreational turf (not home lawns or any other residential turf).			
Bromoxynil (200 g/L) product & 2,4-D amine (625 g/L) product *tank mix of two herbicides* ***Mode of action:*** **Groups 6 (= C) & 4 (= I)**	NSW only; Permit PER12105	***Pastures:*** Pasture.	Apply as an overall spray when fireweed plants are actively growing.	***Boom spray:*** 1.5 L/ha bromoxynil + 1.5 L/ha 2,4-D amine as a tank mix. Ground-based application only, with coarse spray droplet size.	***Withholding period:*** Do not graze or cut for stock food for 8 weeks after application. ***Safety:*** Harmful if inhaled, swallowed or contact with eyes. Irritant. Follow safety directions. ***Off-target risks:*** Risk of legume damage (see previous bromoxynil information above). ***Spray-drift risk:*** Phenoxy herbicides can cause severe damage to native vegetation and susceptible crops including grapes, tomatoes, oilseed crops and ornamentals. Aerial application for fireweed is not allowed under this permit.

Herbicide[a]	State or territory[b]	Registered or permitted situation	Timing	Application[c]	Comments
Diflufenican (25 g/L) + MCPA (250 g/L) ***Mode of action:*** **Groups 12 (= F) & 4 (= I)**	All	***Pastures:*** Newly sown and established clover-based pastures (but see risks). ***Crops:*** Cereals (wheat, barley, triticale, cereal rye, oats), including those undersown with clover.	Suppression of fireweed seedlings up to 4-leaf stage.	***Boom spray:*** 1 L/ha. Do not apply to pastures or weeds that are stressed owing to dry or excessively moist conditions. Do not apply to frost-damaged plants or if frosts are imminent. Good coverage of weeds is essential. Coarse spray droplet size.	***Withholding period:*** Do not graze or cut for stock food for 7 days after application. Sprayed weeds may become more palatable to stock and may result in poisoning. ***Safety:*** Harmful if swallowed or contact with eyes. Irritant. Follow safety directions. ***Off-target risks:*** The tolerance of clover varieties can vary with rate of application, soil type, crop health, stage of growth and degree of moisture and temperature stress. Certain clovers (e.g. rose, strawberry), lucerne and medics can be highly sensitive. Some pasture grasses, including cocksfoot and phalaris, can show initial reduction in growth. Consult the product label. Phenoxy herbicides can cause severe damage to various crops, ornamentals and native plants. ***Other formulations:*** Similar product with differing MCPA herbicide concentration available.
2,4-D (300 g/L) ***Mode of action:*** **Group 4 (= I)**	Qld only One product (Apparent Affray 300) currently registered for use on fireweed in Qld.	***Pastures:*** Pasture. ***Other:*** Non-crop areas.	Apply as an overall spray when fireweed plants are actively growing.	***Spot spray:*** **Handgun:** 700 mL/100 L water. Maximum of 15 L water/ha, with coarse spray droplet size.	***Withholding period:*** Do not graze or cut for stock food for 7 days after application. ***Safety:*** Harmful if inhaled, swallowed or has contact with eyes. Irritant. Follow safety directions. ***Spray-drift risk:*** Not to be applied by a boom sprayer because of risks of spray drift. Phenoxy herbicides can cause severe damage to various crops, ornamentals and native plants.

Herbicide[a]	State or territory[b]	Registered or permitted situation	Timing	Application[c]	Comments
2,4-D amine (625 g/L or 700 g/L) ***Mode of action:*** **Group 4 (= I)**	Qld only; Permit PER13195	***Pastures:*** Pasture (in areas not suitable for ground-based applications).	Apply as an overall spray when fireweed plants are actively growing.	***Helicopter spray application only:*** 2.5–3.0 L/ha or 320 mL/100 L water (for 625 g/L products). 2.2–2.6 L/ha or 285 mL/100 L water (for 700 g/L products). Coarse spray droplet size.	***Withholding period:*** Do not graze or cut for stock food for 7 days after application. ***Safety:*** Harmful if inhaled, swallowed or has contact with eyes. Irritant. Follow safety directions. ***Spray-drift risk:*** Not to be applied by a boom sprayer because of risks of spray drift. Phenoxy herbicides can cause severe damage to various crops, ornamentals and native plants.
Metsulfuron-methyl (600 g/kg) ***Mode of action:*** **Group 2 (= B)**	NSW only; Permit PER87436 Qld only; Permit PER80929	***Pastures:*** Pastures. ***Other:*** Roadsides, non-crop areas, rights of way, forests, reserves and bushlands.	Apply once per year in autumn.	***Boom spray:*** 40 g/ha in 100 L water/ha. ***Spot spray:*** **Handgun:** 10 g/100 L water. **Knapsack:** 1.5 g/15 L water. For spot spraying use at least 1000 L water/ha.	***Withholding period:*** Nil ***Safety:*** Harmful if swallowed. Irritant. Follow safety directions. ***Off-target risks:*** Will kill legumes present in pastures and may impede their regeneration from seed in the following season. Impedes growth of some grasses (e.g. paspalum, setaria) for several months. ***Permit condition:*** may only be applied only once per year.
Aminopyralid (10 g/L) + fluroxypyr (140 g/L) ***Mode of action:*** **Group 4 (= I)**	All Two products currently available: Hotshot® and Choice Shotup Herbicide	***Pastures:*** Pastures. ***Other:*** Agricultural non-crop areas, commercial and industrial areas, rights of way.	Seedlings and flowering plants up to 30 cm tall.	***Boom spray:*** For seedling plants up until flowering, 1.5 L/ha in at least 80 L of water/ha. ***Spot spray:*** For flowering plants – **Handgun:** 500 mL/100 L water. Do not apply when plants are not actively growing, including those stressed because of extreme cold, dry or excessively moist conditions.	***Withholding period:*** Nil mandatory withholding periods for cutting or grazing pastures for stockfeed. However, certain export markets have restrictions – consult the product label. Hay, silage, animal manures or compost intended for use off-farm should not be cut/sent within 6 months of application – consult the product label. ***Safety:*** Damaging to eyes. Irritant. Follow safety directions. ***Off-target risks:*** Will kill legumes present in pastures and impede their regeneration from seed in the following season. Many broadleaved plants are highly susceptible, including vines, vegetables, tomatoes, ornamentals, native vegetation and planted trees. Susceptible crops cannot be planted for up to 20 months – consult the product label. Manage residue risks in farm products.

Herbicide[a]	State or territory[b]	Registered or permitted situation	Timing	Application[c]	Comments
Aminopyralid (8 g/) + picloram (100 g/L) + triclopyr (300 g/L) ***Mode of action:*** **Group 4 (= I)**	All Two products currently available: Grazon® Extra and Extra Grass Herbicide	***Pastures:*** Pastures. ***Other:*** Agricultural non-crop areas, commercial and industrial areas, rights of way.	Flowering plants.	***Spot spray:*** **Handgun:** 350 mL/100 L water **Knapsack:** 53 mL/15 L water Apply as a thorough foliage spray to ensure full coverage of leaves and stems. Do not apply when plants are not actively growing, including those stressed because of extreme cold, dry or excessively moist conditions.	***Withholding period:*** Nil mandatory withholding periods for cutting or grazing pastures for stockfeed. However, certain export markets have restrictions – consult the product label. Hay, silage, animal manures or compost intended for use off-farm should not be cut/sent within 6 months of application – consult the product label. Sprayed weeds may become more palatable to stock, which may result in poisoning. ***Safety:*** Irritant. Follow safety directions. ***Off-target risks:*** Will kill legumes present in pastures and impede their regeneration from seed in the following season. Many broadleaved plants are highly susceptible, including vines, vegetables, tomatoes, ornamentals, native vegetation and planted trees. Susceptible crops cannot be planted for up to 20 months. Consult the product label. Manage residue risks in farm products.
Aminopyralid (25 g/L) + halauxifen (30 g/L) product + fluroxypr (333 g/L) as Starane® Advanced product ***Mode of action:*** **Group 4 (= I)**	All One product currently available: Trezac® Arylex® Active	***Pastures:*** Pastures. ***Other:*** Agricultural non-crop areas, commercial and industrial areas, forests, pastures and rights of way.	Active growth prior to flowering and up to 30 cm tall.	***Spot spray:*** **Handgun:** 200 mL + 210 mL Starane® Advanced /100 L water, as a tank mix. Apply as a thorough foliage spray to ensure full coverage of leaves and stems. Do not apply when plants are not actively growing, including those stressed because of extreme cold, dry or excessively moist conditions.	***Withholding period:*** Nil mandatory withholding periods for cutting or grazing pastures for stockfeed. However, certain export markets have restrictions – consult the product label. Hay, silage, animal manures or compost intended for use off-farm should not be cut/sent within 6 months of application – consult the product label. ***Safety:*** Irritant. Follow safety directions. ***Off-target risks:*** Will kill legumes present in pastures and impede their regeneration from seed in the following season. Many broadleaved plants are highly susceptible, including vines, vegetables, tomatoes, ornamentals, native vegetation and planted trees. Susceptible crops cannot be planted for up to 20 months. Consult the product label. Manage residue risks in farm products.

Herbicide[a]	State or territory[b]	Registered or permitted situation	Timing	Application[c]	Comments
Aminocyclopyrachlor (240 g/L) ***Mode of action:*** **Group 4**	All One product currently available: Method® 240 SL	***Pastures:*** Pastoral grazing land. ***Other:*** Native conservation areas, industrial sites such as railways, roadways and utility rights of way.	Seedlings to flowering plants.	***Spot spray:*** **Handgun:** 200 mL/100 L water. **Knapsack:** 13 mL/15 L water. Use sufficient spray volume to thoroughly and uniformly wet target weed, starting at the top and covering sides. However, avoid spraying to the point of run-off. Apply to actively growing weeds (i.e. not drought or cold-stressed).	***Safety:*** Follow safety directions. ***Off-target risks:*** May injure or kill most crops and may injure or kill desirable vegetation. Certain trees, shrubs, legumes are susceptible to very low doses. May suppress or severely injure certain established grasses. Herbicide in soil can be taken up by plant roots. Beware of contaminating irrigation water. Follow label directions. ***Spray-drift risk:*** Applications should be made only when there is little or no hazard from spray drift – follow label directions. ***Pastures:*** Manufacturer advises that 'pastoral grazing land' is equivalent to 'pastures' (Envu, 2022).
Glyphosate (various concentrations) ***Mode of action:*** **Group M (= 9)**	Qld only; Permit PER11463 NSW and ACT only; Permit PER9907	***Other:*** **Qld permit:** Non-agricultural areas, domestic and public service areas, commercial and industrial areas, bushland/ native forests, roadsides, rights of way, vacant lots, wastelands, wetlands, dunal and coastal areas **NSW permit:** Forests including native vegetation areas, bushland reserve areas, national park areas. Non-cropland, including rights of way, commercial and industrial areas, domestic and urban areas, public service areas, botanic gardens.	Seedlings to flowering plants.	***Spot spray:*** Knapsack: 150 mL/15 L water (for 360 g/L glyphosate products).	***Withholding period:*** Nil for non-agricultural uses. ***Safety:*** Irritant. Follow safety directions. ***Off-target risks:*** Non-selective. Avoid any contact with desirable plants. ***Environmental:*** In aquatic and wetland areas, use only glyphosate products registered for use in such situations.

Herbicide[a]	State or territory[b]	Registered or permitted situation	Timing	Application[c]	Comments
Paraquat (135 g/L) + diquat (115 g/L)	Northern NSW and Qld only	***Crops:*** **Fallows and in direct drilling of crops:** Broadacre crops – winter (cereals, canola, chickpeas, field beans) Broadacre crops – summer (cotton, maize, millet, mung beans, navy beans, peanuts, pigeon peas, safflower, sorghum, soybeans, sunflower).	1- to 12-leaf stage.	***Boom spray:*** 0.8–2.4 L/ha, depending on growth stage and situation.	***Withholding period:*** Do not graze or cut sprayed vegetation for stock food for at least 1 day or graze horses for 7 days after application. ***Safety:*** Very dangerous, particularly the concentrate. Poisonous is absorbed by skin contact, inhalation or swallowing. Irritant. Follow safety directions. ***Off-target risks:*** Broad spectrum contact herbicide, applied before crop emergence.
Sulfometuron-methyl (750g/kg) ***Mode of action:*** **Group 2 (= B)**	Vic, SA, Tas, WA, ACT and southern NSW only	***Other:*** Post-planting of *Eucalyptus globutus*, *E. nitens* plantations, including farm tree plantations.	Bare ground up to 3-leaf stage	***Boom spray:*** 50–70 g/ha in 100 L water/ha. Applied as an inter-row directed spray using a shielded sprayer. ***Spot spray:*** **Handgun:** 5–7 g/100 L water. **Knapsack:** 7.5–10.5 g/15 L water. Use higher rate for longer term residual control.	***Withholding period:*** Nil. ***Safety:*** Irritant. Follow safety directions. ***Off-target risks:*** Soil residual herbicide. Allow 12 months after the transplanting of tree seedlings before applying the chemical. Direct drift or spray onto any part of a Eucalypt seedling will result in severe injury or death.

[a] Mode of action categorisation is transitioning from the Australian letter system to the international number system (CropLife Australia, 2022).

[b] Products may be registered for use on fireweed in all states and territories (shown as 'All') or only in the specific states and territories listed. Further, additional uses not listed on the label may be allowed under permit, for specified states or territories. If a state or territory is not listed on the label and there is no applicable permit, use as specified on the label for the same situation may still be allowed under jurisdictional legislation, where considered low risk – seek government advice.

[c] Application rates are general advice only and may vary between products. Check the product label for specified rates and application methods (or the permit, as applicable).

5.5 State/territory contacts for weed control information

State and territory government departments provide information on controlling weeds. Contact details are provided in Table 5.9. Local/regional weed management authorities can also be contacted for information and advice.

Table 5.9 Contact details of state and territory departments for weed management (May 2023).

State/ territory	Department	Phone	Email	Website
ACT	ACT Parks and Conservation Service	13 22 81	ACTBiosecurity@act.gov.au	www.environment.act.gov.au/parks-conservation/plants-and-animals/biosecurity/invasive-plants
NSW	Department of Primary Industries	1800 680 244	weeds@dpi.nsw.gov.au	www.dpi.nsw.gov.au/biosecurity/weeds
NT	Department of Environment, Parks and Water Security	08 8999 4567	weedinfo@nt.gov.au	www.nt.gov.au/environment/weeds
Qld	Department of Agriculture and Fisheries	13 25 23	info@daf.qld.gov.au	www.daf.qld.gov.au/business-priorities/biosecurity/invasive-plants-animals/plants-weeds
SA	Department of Primary Industries and Regions	08 8303 9620	invasivespecies@sa.gov.au	www.pir.sa.gov.au/biosecurity/weeds
TAS	Department of Natural Resources and Environment Tasmania	1300 368 550	biosecurity.tasmania@nre.tas.gov.au	www.nre.tas.gov.au/invasive-species/weeds
Vic	Agriculture Victoria	13 61 86	Refer to www.agriculture.vic.gov.au for contact options	www.agriculture.vic.gov.au/biosecurity/weeds
WA	Department of Primary Industries and Regional Development	1300 374 731	enquiries@dpird.wa.gov.au	www.agric.wa.gov.au/pests-weeds-diseases/weeds

5.6 Property planning resources

The following tables provide sources of online guidance for property-level planning regarding overall property management, biosecurity management and weed management. The tables are not exhaustive and new resources and initiatives may be become available.

Table 5.10 Sources of online information on property management planning (May 2023).

Source	Web link	Description
Queensland Government **Farm Business Resilience Program**	www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/disaster/drought/assistance/business-resilience-plan	Helps farmers and graziers to prepare for and manage business and climate risks.
Local Land Services NSW **Farm planning – setting your vision for your land**	www.lls.nsw.gov.au/what-we-do/our-major-projects/every-bit-counts/resources/rural-property-ownership/property-management/farm-planning-setting-your-vision-for-your-land	Outlines how to undertake a basic property planning.
Dairy Australia **Our Farm, Our Plan**	www.dairyaustralia.com.au/farm-business/our-farm-our-plan#.Y2SpaWIBwQ8	Provides resources and templates, supported by workshops for eligible farmers.
Dairy NZ **Farm business planning**	www.dairynz.co.nz/business/planning/	Has templates and guides. General principles apply to Australian livestock enterprises.
Agriculture Victoria **Land Health**	agriculture.vic.gov.au/farm-management/land-and-pasture-management/land-health	Outlines farm planning services provided through the Victorian government.

Table 5.11 Sources of online information on property biosecurity planning (May 2023).

Source	Web link	Description
Animal Health Australia (AHA) and **Plant Health Australia (PHA)** **Farm Biosecurity Program** *(joint initiative)*	www.farmbiosecurity.com.au	This website is a national hub of farm biosecurity information. It includes information to help producers understand disease, pest and weed risks, what they can do to reduce those risks, and how to go about it. It provides information and tools, including an app, to help producers implement biosecurity measures on their property.
Animal Health Australia (AHA) **Better On-farm Biosecurity**	animalhealthaustralia.com.au/better-on-farm-biosecurity/	AHA has an on-farm biosecurity plan template for livestock enterprises, including beef and dairy cattle, sheep, goats and alpaca.
Integrity Systems **Livestock Production Assurance (LPA)**	www.integritysystems.com.au/on-farm-assurance/Biosecurity/	The LPA program is the Australian red meat industry's on-farm assurance program, providing evidence of livestock history and on-farm practices when transferring animals through the value chain. It includes a requirement to have a farm biosecurity plan and provides a template (similar to that provided by AHA).

Queensland Government Department of Agriculture and Fisheries On-farm biosecurity	www.daf.qld.gov.au/news-media/campaigns/on-farm-biosecurity	This state government website explains how to meet legal requirements to prevent or minimise the spread of biosecurity risks, including weeds.
NSW Government Department of Primary Industries Your role in Biosecurity	www.dpi.nsw.gov.au/biosecurity/your-role-in-biosecurity	This state government website explains how to meet legal requirements to prevent or minimise the spread of biosecurity risks, including weeds.
NSW Government and Small Farms and Rural Living Network Building biosecurity for small farms	www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/1155931/Building-biosecurity-for-small-farms.pdf	A biosecurity guide for small farms and lifestyle properties.
Western Australian Government Biosecurity plans for small landholders	www.agric.wa.gov.au/small-landholders-western-australia/biosecurity-plans-small-landholders?nopaging=1	The website is broadly applicable across Australia.

Table 5.12 Sources of online information on property weed management planning (May 2023).

Source	Web link	Description
Local Land Services NSW South East Preparing a Whole of Property Weed Management Plan	www.lls.nsw.gov.au/regions/south-east/articles,-plans-and-publications (Filter by Topic of Weeds)	Provides a guide and template for preparing a property weed management plan.
NRM North (Tasmania) Guide for Developing a Weed Management Plan	nrmnorth.org.au/resources/ (Search for 'weed plan')	Provides general guidance on how to develop a best practice plan for weed management.
Meat & Livestock Australia (MLA) Weed control hub	www.mla.com.au/extension-training-and-tools/feedbase-hub/weed-control/	The hub details six principles that provide the basis for an effective pasture weed control plan.
University of New England Weed Detection and Control on Small Farms	www.une.edu.au/__data/assets/pdf_file/0004/23575/2010-Weed-Detection-and-Control-on-Small-Farms-A-Guide-for-Owners.pdf	The guide describes pathways of weed spread to farms, where to look for weeds and how to control them.
Queensland Government Vehicle and machinery clean-down procedures	www.daf.qld.gov.au/__data/assets/pdf_file/0011/58178/cleandown-procedures.pdf	The site gives detailed guidance on how to prevent weed movement by such means.
Victorian Serrated Tussock Working Party Best Practice Serrated Tussock Weed Hygiene Guide	serratedtussock.com/ (Search for 'hygiene guide')	The guide is broadly applicable to preventing and stopping the spread of pasture weeds.

5.7 References

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Notes

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