



Weeds of National Significance

National Best Practice
Management Manual

Serrated Tussock



Current management and control options for
serrated tussock (*Nassella trichotoma*) in Australia

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This manual is part of the National Strategy for Serrated Tussock, managed by Bronwen Wicks, National Serrated Tussock Coordinator, Department of Primary Industries, New South Wales.

For further information on the Weeds of National Significance Program visit the Weeds Australia website www.weeds.org.au/WoNS/serratedtussock

Copies of this manual can be downloaded or ordered from the above website or contact the National Serrated Tussock Coordinator directly at: tussock.management@dpi.nsw.gov.au

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Cover photography:

Front top left: Seeds are a distinctive purple colour. (Charles Grech)

Front middle: Tussock can grow to 60 cm high. (Natasha Baldyga)

Front top right: Identify serrated tussock. (DPI Victoria)

Front bottom: Conservation native grasslands. (Steve Taylor)

Back: Native pasture-high infestation. (Aaron Simmons)

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Department of
Primary Industries



NATIONAL
SERRATED
TUSSOCK
MANAGEMENT
GROUP



Australian Government



Acknowledgements

Principle authors

Rachele Osmond, Consultant

Miriam Verbeek, Consultant, Profit Foundation Pty Limited

Participating writers

David McLaren, Department of Primary Industries, Victoria

Michael Michelmore, Department of Primary Industries, NSW

Bronwen Wicks, Department of Primary Industries, NSW

Charles Grech, Department of Primary Industries, Victoria

Peter Fullerton, Department of Primary Industries, Victoria

Case study contributions from

Robert Hyles, Farmer, Australian Capital Territory (ACT)

Sally and Tid Alston, Farmers, Victoria

Len and Geoff Menzel, Farmers, Victoria

Luke Pope, Department of Primary Industries, NSW

Nick Jacobs, Parks and Wildlife Group, Department of Environment and Climate Change, NSW

Rod Thomas, Melton Shire Council, Victoria

Natasha Baldyga, City of Whittlesea, Victoria

Don Clinton, Snowy River Shire Council, NSW

Aaron Simmons, Charles Sturt University, NSW

Andrew Crane, Department of Primary Industries and Water, Tasmania

Steve Taylor, Parks, Conservation and Lands, ACT

John Hyles, Farmer, NSW

Robert Friend, Farmer, NSW

Alan McKenzie, Farmer, Victoria

Technical reference group

David McLaren, Department of Primary Industries, Victoria

Peter Fullerton, Department of Primary Industries, Victoria

Charles Grech, Department of Primary Industries, Victoria

Birgitte Verbeek, Department of Primary Industries, NSW

Bronwen Wicks, Department of Primary Industries, NSW

Aaron Simmons, Charles Sturt University, NSW

Byron Crowe, Department of Primary Industries, Victoria

Karen Stewart, Department of Primary Industries and Water, Tasmania

Luke Pope, Department of Primary Industries, NSW

Michael Michelmore, Department of Primary Industries, NSW

Desktop publishing

Kathryn Parker, Department Primary Industries, Victoria

Contributions from National Serrated Tussock Management Group

Scott Chirnside (chair), Victoria

Andrew Crane, Tasmania

Byron Crowe, Victoria

Syd Lisle, NSW

James Browning, NSW

Jim Seager, Victoria

Steve Taylor (corresponding member), ACT

Bronwen Wicks, National Serrated Tussock Coordinator

Georgie Bailey, Australian government

John Thorp, WoNS National Facilitator

Contributions (including technical input, review, comments, photos)

Fiona Leech, Department of Primary Industries, NSW

Linda Ayres, Department of Primary Industries, NSW

Chelsea Wardrope, Department of Primary Industries, Victoria

Meredith Mitchell, Department of Primary Industries, Victoria

Lori McWhirter, Department of Primary Industries, NSW

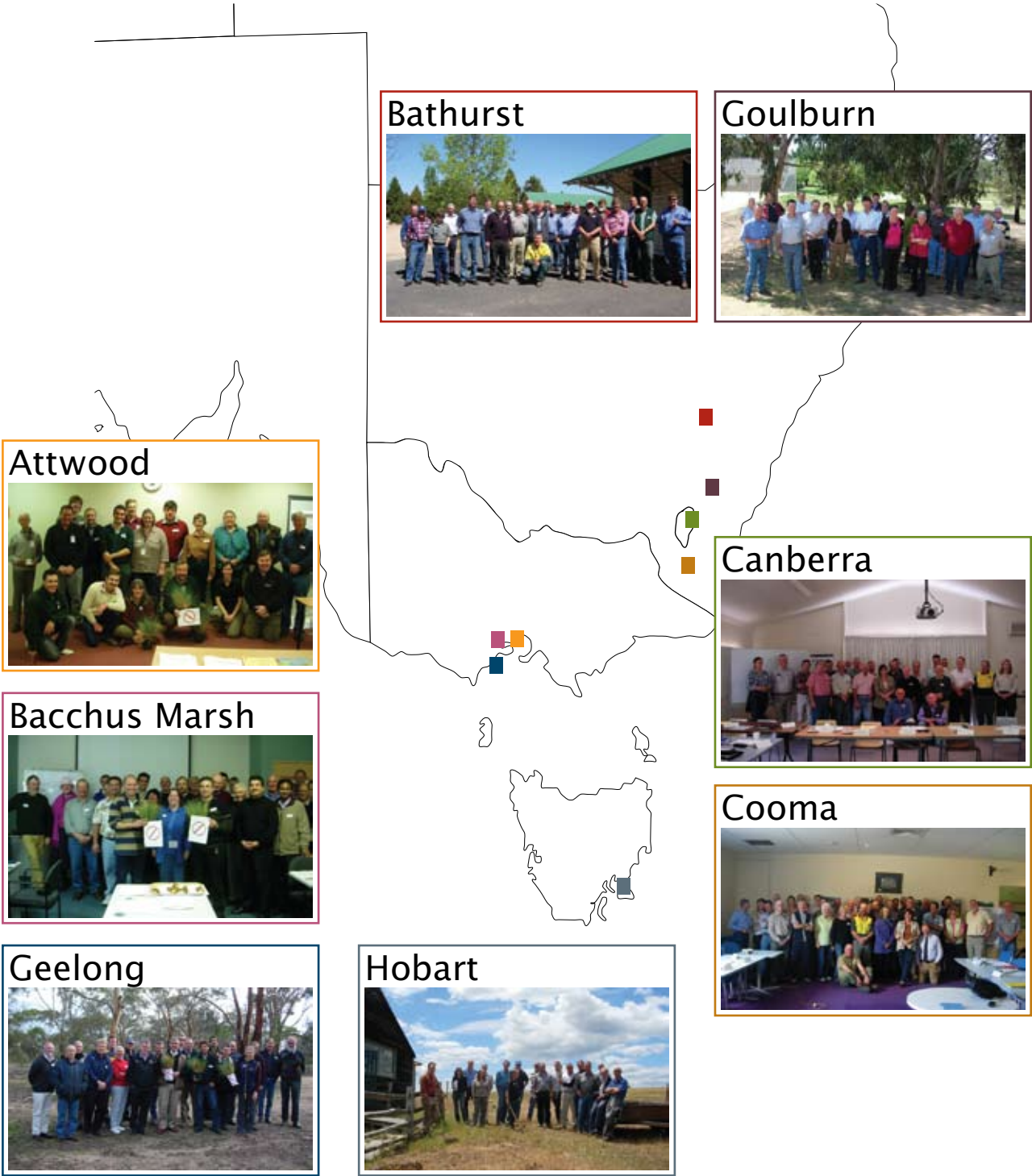
James Browning, New England Weeds Authority, NSW

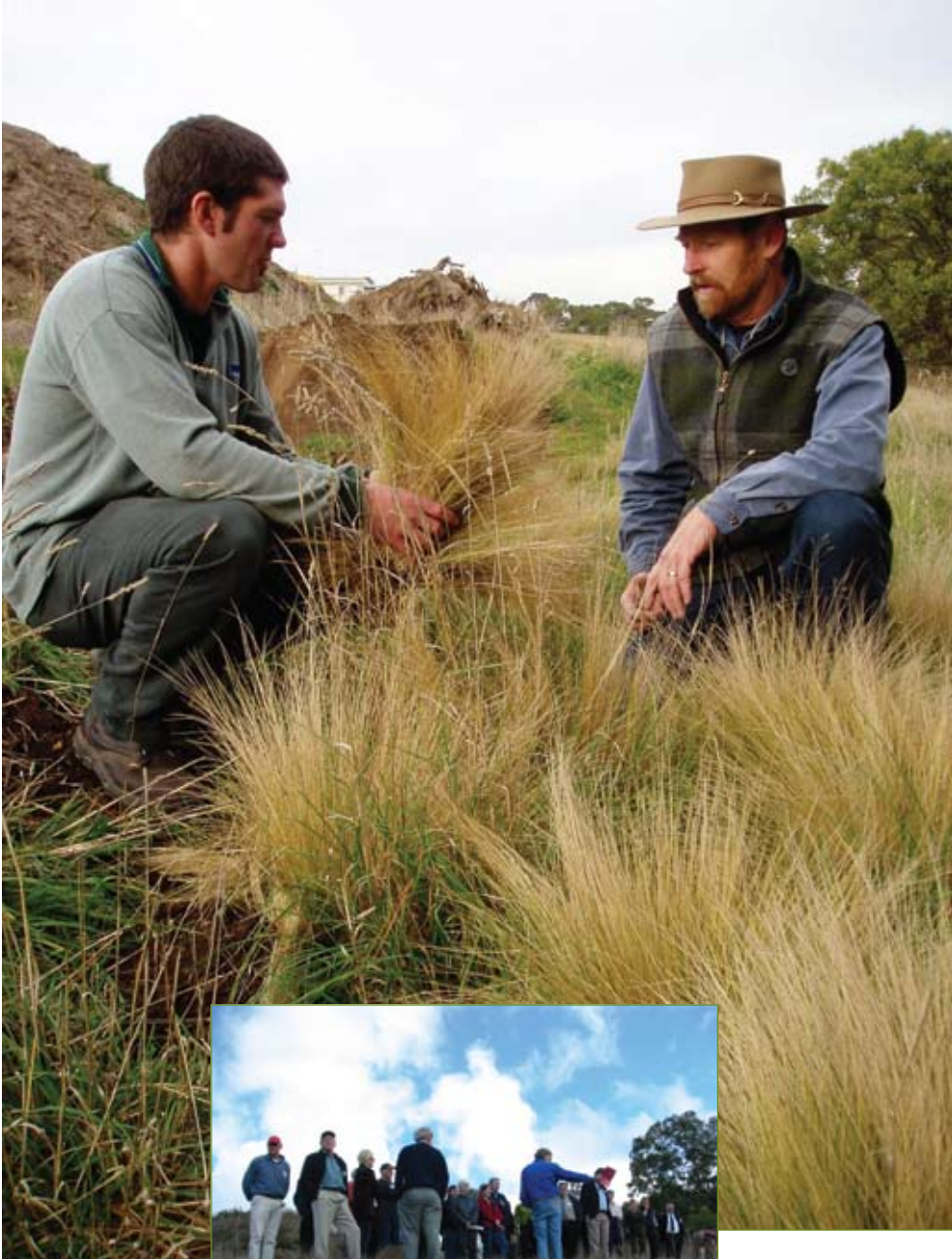
Michael Laity, Department Primary Industries, Vic

All 206 participants of the serrated tussock weed management workshops held at Attwood, Bacchus Marsh, Bathurst, Canberra, Cooma, Geelong, Goulburn and Hobart

Serrated tussock Best Practice Management Workshops

To assist the development of this manual, eight serrated tussock best practice management workshops were conducted across Australia. Over 200 participants; representing farmers, shires, state and local government weeds officers, utilities, scientists, and environmental and natural resource management professionals were involved. Some of these participants also contributed case studies for the manual.





DPI Victoria

Foreword

Serrated tussock is a word which can strike fear into any farmer or land manager that is familiar with it. It is one of the worst perennial grass weeds in Australia invading pastures, native grasslands and urban areas covering more than a million hectares in New South Wales, Victoria, Tasmania and the ACT. But these words and figures alone don't fully describe the impact that serrated tussock has had on Australia's grazing lands and native grasslands. Tussock, left unmanaged, has the capacity to greatly reduce productivity of grazing lands, impact on biodiversity values and in inaccessible and difficult to manage areas, can be a continuous source of seed for whole regions and communities.

In our increasingly uncertain climatic times, serrated tussock is a plant that has great capacity to survive and further expand its spread. It can tolerate extremes of temperature, low rainfall and low soil fertility. With its prolific seed production and ability to spread by wind, livestock, machinery and transport networks it is well suited to rapidly advance over new areas in the temperate zone, colonising bare patches of ground and changing landscapes forever.

Effective long-term management of serrated tussock exemplifies some of the key challenges of our time. How can we work together as a community and individuals to better manage our land while maintaining our livelihoods **and** the things we value and want to pass on to future generations? There are no easy answers to these questions.

It is only by taking individual and collective responsibility for this situation that we will be able to move forward. Like the Alcoholics Anonymous 12 steps we all need to acknowledge firstly that we have a problem, rather than blame everybody else for it. Only then will we be able to make steps forward to find solutions as individuals and as larger groups.



Scott Chirnside
Chair,
National Serrated Tussock Management Group

I, personally, have seen many positive measures put in place and the strength that comes when communities work together to combat the invasion by serrated tussock. Community means everyone – all levels of government, Landcare, neighbours, regional NRM bodies, weed officers, schools, farming organisations, land managers and land owners. When we are working together towards a shared vision and building constructive relationships across the community we have the greatest opportunity to manage our landscapes sustainably, and thus create a robustness in our systems to help combat weed invasion from not only serrated tussock but all weeds.

The National Serrated Tussock Management Group recognises the need to contain the spread of serrated tussock and to control existing infestations, as well as the need to provide best practice information to those attempting to carry out these often daunting tasks. Equally we recognise the need to replace treated serrated tussock with other species and grasses that can compete with the next generation of tussock seedlings or any other opportunistic weed. The Serrated Tussock Best Practice Manual is an important link in this chain.

Designed to help provide effective management solutions for serrated tussock within a broader context of integrated weed management, the manual brings together detailed information about the plant itself, as well as best practice information about existing control and management options.

I recommend this manual to weed control authorities and to all land managers in the government, corporate and private sectors — for all of us are responsible for land that is affected, or at risk of invasion, by serrated tussock.

How to use this manual

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

While serrated tussock is a challenging weed to control, it is hoped that this manual will provide the necessary tools and knowledge to successfully manage serrated tussock. It is important that the information provided is adapted by each individual to reflect their own environmental, financial and social circumstances.

The manual has been designed to allow easy access to the information and includes the following features:

- an index of keywords for quick and easy access to specific information
- a glossary of key terms and abbreviations
- chapters are colour coded to help access information quickly
- an 'at a glance' control table outlining the range of control and management tools applicable for different land-uses
- best practice control and management information described in detail for agricultural, conservation and urban land-uses.

The information is divided into six sections

Section 1 *The serrated tussock profile*

- What is serrated tussock and why is it a problem?
- What does it look like?
- What do other similar grasses look like and how are they different?
- How does it spread?

Section 2 *Integrated weed management*

- What is integrated weed management?
- How do I prioritise areas for control?
- How does serrated tussock affect communities?
- How do I develop a weed control plan?

Section 3 *Selecting a control program*

- Which control methods are best to use for my situation?
- How should I integrate control methods in my situation?
- Why didn't the method I used work?

Section 4 *How to implement control methods and management practices*

- What is the best time to apply control?
- How can I get the best results from a specific method?
- What are the pros and cons of a control method?

Section 5 *Case studies*

- What are other land managers doing?
- What has been tried on land that is hard to access?
- How have others managed grazing land and kept it productive?

Section 6

- Is serrated tussock a declared plant where I live?
- Who can I contact if I need more help?
- What other information is available on serrated tussock?
- What do some of the terms used in the manual mean?

Where does the information come from?

The information has been sourced from published information, existing research, reviews by technical experts, and the experiences of individuals and organisations currently managing serrated tussock in Australia. It also incorporates the outcomes from a series of serrated tussock weed management workshops held throughout south-east Australia in 2007.

While this manual aims to provide the most current information and understanding of best practice for serrated tussock, it is by no means the final word. Approaches for serrated tussock management can be expected to evolve and adapt into the future as research unfolds and the experiences of land managers continues to grow.

We would appreciate feedback on the manual—whether you found it useful and what could be improved. Please email with your feedback to National Serrated Tussock management group: tussock.management@dpi.nsw.gov.au

If, in the course of your management of serrated tussock, you find anything out of the ordinary or you trial a control method that is particularly effective, please email this information to National Serrated Tussock management group at tussock.management@dpi.nsw.gov.au to share with others. This way the best practise manual (BPM) will always be improving and based on the real experience of land managers and owners.

A copy of the serrated tussock resource CD is enclosed with this manual. This CD includes a copy of the BPM but contains many other useful resources including Department of Primary Industries agricultural notes, serrated tussock research papers, identification photos and other useful information. Further copies of the manual and CD can be obtained from the NSW DPI bookshop (ph: 1800 028 374 em: bookshop@dpi.nsw.gov.au) or can be downloaded from www.weeds.org.au/WoNS/serratedtussock. The manual can also be obtained through the Victorian DPI Service Centre (ph: 136 186) copies will also be available at Victorian regional DPI centres.



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Section 1

The serrated tussock profile

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Impact of serrated tussock in Australia

Serrated tussock is a highly invasive weed of temperate Australia. It is one of Australia's worst weeds and was selected as a Weed of National Significance due to its invasiveness, potential for spread and social, economic and environmental impacts (Thorpe and Lynch 2000).

Being similar in appearance to many native tussock grasses, serrated tussock is able to go unnoticed in both pastures and native grasslands for many years until significant infestations have developed.

It will readily invade pastures, native grasslands, grassy woodlands and roadsides. Being a weed that is mostly dispersed by wind, it will easily spread between paddocks and properties within a region. Serrated tussock is a weed that can cause many complex issues within the communities that it occurs, requiring long-term management and a community/regional approach.

Serrated tussock is a drought tolerant species and the increasing temperatures resulting from climate change may see this weed become more competitive in future years. It thrives in low rainfall habitats (400–500 mm) and its prolific wind dispersed seeds may be dispersed even further during extreme weather conditions (heat and wind). Recent drought conditions have resulted in increased bare ground providing ideal habitat for serrated tussock regeneration. Land managers must be particularly vigilant of serrated tussock regeneration and its management after drought.

A national strategy for serrated tussock has been developed to reduce its impact and to prevent its spread and establishment across Australia.

Agriculture

Serrated tussock is an invasive weed of pastures, having the potential to infest entire properties. It has been described as causing a greater reduction of pasture and grazing carrying capacity than any other weed in Australia.

Pastures that can normally carry 7–15 dry sheep equivalent (DSE) per hectare (ha) can be reduced to a carrying capacity of only 0.5 DSE per hectare if heavily infested with serrated tussock (Campbell and Vere 1995). In NSW alone, it is estimated that serrated tussock has cost more than \$40 million per year in control and lost production and \$5 million per year for its control in Victoria.

Serrated tussock is unpalatable to livestock and will only be eaten if nothing else is available. It is of low nutritional value to livestock, with plant digestibilities in the range of 30% to 51% and metabolisable energy levels ranging from 4 MJ/kg DM (megajoules per kilogram of dry matter) to 7 MJ/kg DM. Any feed of this quality is insufficient to meet livestock requirements. If livestock are forced to graze pastures containing only serrated tussock, the leaves can form indigestible balls in the rumen, causing a loss of condition and eventual death.

Serrated tussock seed is a contaminant of hay, can remain viable in the gut of livestock for up to 10 days and can attach to vehicles, machinery and equipment. All of these mechanisms have the potential to spread serrated tussock over long distances.



Ryan Melville

Serrated tussock can invade grazing land, reducing carrying capacity.



Robert Hyles

A typical scenario—heavily infested hills of serrated tussock may provide a seed source for productive agricultural land.

Serrated tussock is an aggressive weed that affects agriculture, conservation and urban areas.

Native Grasslands

Native grasslands are one of Australia's most threatened ecosystems. Less than one per cent of their original extent remains (Ross 1999) and these are in various stages of degradation throughout south-east Australia. Two native grasslands communities have now been listed as endangered under the Commonwealth's Environment Protection and Biodiversity Conservation Act (1999)—1. The Victorian volcanic plain temperate grasslands and 2. The natural temperate grasslands of the southern tablelands of New South Wales (NSW) and Australian Capital Territory (ACT).

Often high quality native grasslands are small, remnant areas occurring where human land-use has not had a significant affect. Serrated tussock is a key threat to native grasslands. Being very similar in appearance to many of temperate Australia's native grasses, it is able to go unnoticed in grasslands for many years. Unfortunately by the time it is recognised, the native grasses have been replaced by significant infestations of serrated tussock.

Serrated tussock has already invaded many of temperate south-eastern Australia's most endangered native grassland remnants and its presence is a serious threat to the native flora and fauna of these grasslands.

While serrated tussock is mostly a problem reducing the biodiversity values of native grasslands, it can also invade other environmentally significant areas such as dry coastal vegetation, grassy woodlands and sclerophyll forests.

Common native grassland species include kangaroo grass (*Themeda triandra*), wallaby grasses (*Austrodanthonia* spp.), spear grasses (*Austrostipa* spp.) and native tussock grasses (for example, *Poa* spp.).

Native grasses that are often confused with serrated tussock include:

- poa/silver tussock (*Poa labillardieri*)
- snow grass (*Poa sieberiana*)
- red anther wallaby grass (*Joycea pallida*)
- spear grass (*Austrostipa* spp.)
- wallaby grass (*Austrodanthonia* spp.)
- kangaroo grass (*Themeda triandra*).



Native grasslands are at risk of serrated tussock invasion.

Charles Grech



Native flowers.

DPI Victoria

Urban situations

Roadsides, parks, neglected areas, railways, power line easements, reserves and sporting grounds are all areas where serrated tussock can be a weed in cities and towns. These areas can be a source of seed spread by wind, vehicle movement or maintenance activities such as slashing. Some of these areas may also contain or be adjacent to remnant native grasslands.

Large build-ups of serrated tussock are a concern in urban areas because of the increased fire risk and hazard because:

- fire intensity is increased due to the dryness and large biomass of combustible material in serrated tussock
- seed heads can catch fire and then blow away, capable of starting fires some distance away
- seed heads can be blown up into the eaves of homes
- the fire season is lengthened in areas where large infestations occur.

The seed of serrated tussock may also be spread throughout urban areas by mud on the hooves of horses, by sticking to the coats of pets, or by human movement or activities.



Simon Bonwick

Serrated tussock infesting an urban road side.



Bronwen Wicks

Serrated tussock can be a fire risk in situations such as this.

Distribution and preferred habitat in Australia

Current distribution

Serrated tussock is native to the South American countries of Argentina, Uruguay, Chile and Peru. It was thought to be first introduced to Australia in the early 1900's, but was not officially recorded until 1935 at Yass, New South Wales where it has since expanded its distribution dramatically. Light to dense serrated tussock infestations now occupy 860,000 ha of NSW, with scattered infestations over a further 1.2 million ha. The main areas affected by serrated tussock in NSW are the northern, southern and central Tablelands, and Monaro region.

A patch of approximately 4 ha was first recorded in Victoria in 1954 in Broadmeadows (a suburb of Melbourne). This small patch had expanded to 30,000 ha by 1980 and then to 130,000 ha by 1998. In 1995 a co-ordinated serrated tussock management program was established in Victoria to help reduce the infestation levels of serrated tussock. The program, facilitated by the Victorian Serrated Tussock Working Party, has been able to significantly reduce infestation levels in Victoria down to 85,000 ha, with 45,000 ha currently under long term control. Main infestations occur in the Melbourne, Geelong and Ballarat areas of Victoria.

Serrated tussock was first recorded in Tasmania in 1956 at Sandford near Hobart, although it had been known in the area since the late 1920s. By 1965 it was estimated that 3200 ha of land was

Serrated tussock currently covers more than 2 million hectares of land in south-east Australia and has the potential to spread even further.

infested. A state-funded eradication program undertaken in the 1970s and 1980s substantially reduced the infestation size. More recent discoveries of serrated tussock on the state's east coast, in the north and on King Island have resulted in renewed efforts to control isolated and outlier infestations. There is currently approximately 1700 ha still infested in Tasmania.

On a global scale, serrated tussock has naturalised and is considered weedy in New Zealand and South Africa. Small infestations also occur in England, France, Italy, Scotland and the United States.

In south-eastern Australia serrated tussock is now widespread and covers more than 2 million ha of land. It has occasionally been found, and eradicated, in South Australia. To date, it has not been found in Queensland, Western Australia or the Northern Territory.

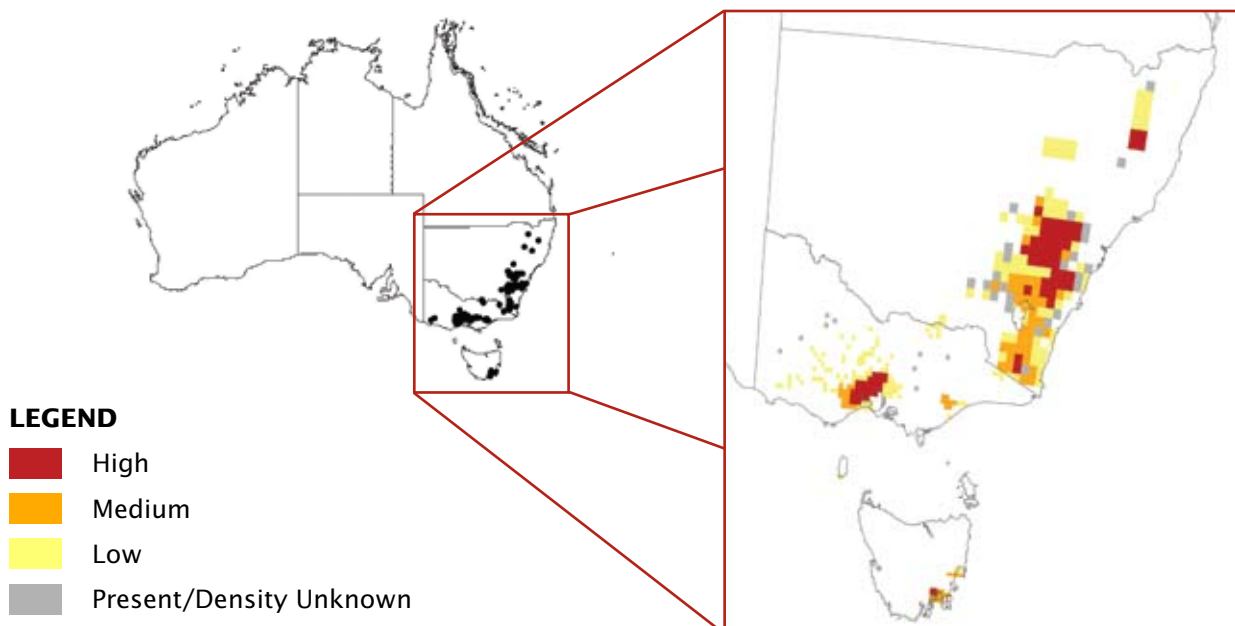


Figure 1: Current distribution of serrated tussock in Australia.

Potential distribution in Australia

Using the climate modelling system CLIMATE®, the potential distribution of serrated tussock, based on the climatic parameters of current infestations in Australia, has been estimated at 32 million ha. Substantial additional areas of New South Wales, Victoria and Tasmania are shown to be at risk of invasion.

While this map is a useful guide, it may overestimate potential distribution. This is because the prediction is based on the climate of known distributions of serrated tussock in Australia, but does not take into consideration other factors that may be of importance such as soil type, day length and other biological factors.

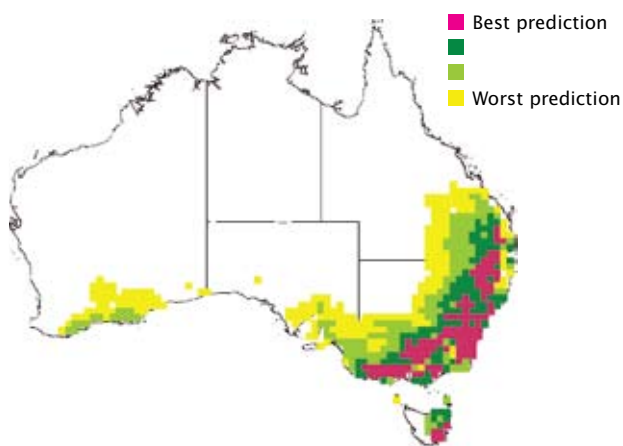


Figure 2: Potential distribution of serrated tussock in Australia using the CLIMATE® modelling system.

Preferred habitat

Serrated tussock is a drought tolerant plant that is adapted to a wide range of climates and soil types. It will readily invade pastures, native grasslands and open scrub, and will grow on all types of terrain and different aspects.

It will quickly infest bare ground and areas that have been disturbed, such as roadsides, overgrazed pastures or cultivated situations. It will colonise steep, rocky and timbered areas. These characteristics enable serrated tussock to quickly establish after times of drought.

Serrated tussock does not like to grow in heavily shaded areas, such as under a dense canopy of trees, or in damp or swampy ground.

It is capable of withstanding a range of climates, but prefers cool temperate areas with an annual rainfall ranging 450–1000 mm. It does not tend to grow well in areas that experience hot summers (average over 30°C) and can tolerate freezing conditions.

Serrated tussock is not limited by soil type or fertility and will often be found growing in soil where there is little nutrition and/or low water. It grows on soils derived from slate, shale, limestone, ironstone, granite, basalt, sandstone, and mudstone (Campbell and Vere 1995).

Serrated tussock will readily grow in acidic soils but is rarely found in soils affected by salinity or waterlogging, preferring well drained areas to become established. While it will grow in very infertile soil, it also responds well to nitrogen or phosphorus fertiliser. Serrated tussock plants growing in fertile soil will often be larger in size than those growing in areas of low soil fertility.



Natasha Baldyga

Serrated tussock will quickly invade bare ground.

Serrated tussock can survive and thrive in many environments.

Biology of serrated tussock

Description

Serrated tussock is a perennial grass that can grow up to 60 cm in height and 25 cm in diameter at the base of the plant. When in flower, the drooping seed heads can give the plant an overall diameter of up to 75 cm.

The height of plants can vary depending on soil fertility and location. Plants growing in fertile soils are capable of growing to 60 cm high while plants growing in infertile conditions are more likely to reach a height of only 15 cm. Serrated tussock growing in Victoria will generally be smaller in height than serrated tussock growing in NSW, ACT or Tasmania.

It has an extensive network of fibrous roots which exist mostly in the top 20 cm of soil, although some do occur deeper. They are dense, wiry and fibrous, making serrated tussock very difficult to pull out even when small.

At present, there appears to be two different strains of serrated tussock growing in Australia. While they are genetically the same, some features of the plant may differ.



Michael Michelmore

Serrated tussock seed head.



DPI Victoria;



Natasha Baldyga

Tussock can grow to 60 cm high.

Life cycle

Germination mainly occurs through autumn and winter (Mar–Aug) but may occur at any time of the year following significant rainfall and in response to soil disturbance. Germination occurs at similar times across all States.

Seedlings are weak and slow growing and are more likely to establish on bare ground with limited competition. Their establishment is critical over the summer months. It is during this time that if seedlings become stressed by competition for moisture and light, their chance of survival is reduced.

Active growth of established plants mainly occurs in favourable autumns and in spring and early summer (Sept–Dec) when sufficient soil moisture is available.

Flowering stems emerge from the base of the tussock as early as late winter (Aug) and will continue throughout the spring (Sept–Nov). Severe drought can stop plants from flowering. Autumn flowering has been known to occur if plants do not flower in spring.

The flowering stem/seed head is a panicle (multi-branched) up to 35 cm long. At each junction, there are two or three branches that lead to a single seed or another set of small branches. The purple colour of small seeds produces an overall purplish haze to the serrated tussock seed head. Once the seeds have formed, the entire seed head will 'droop' over the tussock towards the ground.

Only 10–15% of serrated tussock flowers will open, making them available for cross pollination with other serrated tussock plants. The remaining 85–90% of the flowers self pollinate, which will produce a clone of the parent plant. This has implications for herbicide resistance because a resistant plant can produce many thousands of resistant seeds (see page 24).

Key features of serrated tussock lifecycle include:

- it is perennial
- only reproduces by seed – producing tens of thousands of small seeds on large structural panicle stalks
- dispersal is mostly by wind
- once flowering is initiated, seed-set will occur within 8–10 weeks
- seedlings are slow growing and vulnerable to competition by other more vigorous growing species
- little growth occurs during winter months
- individual plants can live for many years
- able to quickly respond to changing environmental conditions. For example, may flower and set seed within 12 months (known in Victoria) or may take as long as 3 years in drought and low fertility situations.



Seeds take 8–10 weeks to mature once the flowering stems emerge. This will normally occur throughout the spring and summer months. Once seeds are ripe, the whole flowering stem detaches from the base of the plant and is dispersed by the wind. Seed is dormant when first dispersed and will not germinate until dormancy has broken (approximately 6 months).

Bleaching from frost may occur in late autumn and winter, turning the plant golden yellow in colour – which can help identification in winter.

A general indication of the lifecycle and growth pattern of serrated tussock throughout the year is shown in Table 1. Please note that the timing of different stages can vary, being earlier or later, depending on rainfall, temperature and soil fertility.

State		SPRING			SUMMER			AUTUMN			WINTER		
		Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug
All	Germination												
All	Bleaching due to frost												
Vic / Tas	Flowering												
Vic / Tas	Seed formation												
Vic / Tas	Seed drop												
NSW / ACT	Flowering												
NSW / ACT	Seed formation												
NSW / ACT	Seed drop												

Table 1: General growth pattern of serrated tussock

 = general pattern of growth;  = growth pattern under favourable conditions#.

= Favourable conditions generally mean high soil fertility and following periods of significant rainfall or soil disturbance.

The serrated tussock lifecycle has some vulnerable characteristics that may be targeted to assist with control. Some key features to target include:

- Control before serrated tussock sets seed—this will prevent seed-set and prevent addition of tens of thousands of seeds added to the soil seed bank.
- Seedlings are slow growing and vulnerable to competition—maintaining a healthy vigorous pasture will reduce the occurrence of seedling establishment.
- Limit soil disturbance—seeds will quickly germinate following soil disturbance, particularly if bare ground is available.

While anecdotal reports state that serrated tussock seed can remain viable in the soil for more than 20 years, the actual length of time may be significantly shorter. Research has shown that the germinability of serrated tussock seed can reduce quite rapidly, with approximately 74–91% of the seed bank reducing over a 6–12 month period.

While there may still be large numbers of seed still present in the soil, this information may provide land managers some comfort knowing that if you prevent serrated tussock from seeding, the viability of the seeds in the soil are also declining. Preventing seed-set over a number of years will have a substantial impact on decreasing the number of viable seeds in the seed bank.

Seed bank

Serrated tussock is a prolific seeding plant. A single mature plant can produce more than 100 000 seeds per year, quickly forming a very large soil seed bank. As one plant is capable of producing such large quantities of seed, the seed bank can be quickly replenished.

Serrated tussock seed banks can decline quickly if land managers stop serrated tussock seeding.

Seed spread

The seeds of serrated tussock are mostly spread by wind, but can also be spread by machinery and vehicles; in hay and fodder; as a contaminant of wool and clothing; by water; mud and in the droppings of grazing animals.



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Serrated tussock can quickly spread throughout an area, rapidly forming a monoculture.

Wind

The serrated tussock seeds are well adapted to wind dispersal and this is the main way it spreads. Once seeds are mature, the entire seed head breaks away from the base of the tussock and blows along the ground with surface winds, and sometimes with thermals. Wind currents can influence where a mass of seed heads will land and can often be seen on the crown and crest of hills.

While most of the seed will remain relatively close to the adult plant (within 0.5 km), seed heads are light and able to travel great distances (up to 20 km). Masses of seed heads can be captured by fences, trees, logs, gullies and other obstructions. Seeds are then able to germinate, forming new colonies of serrated tussock.

Re-invasion from neighbouring properties and public lands from air-borne seeds can be a problem if control is not tackled as a community effort.

Seeds can be spread large distances by wind, vehicles, animals, people and water.



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Wind swept seed heads can be captured by mesh fencing.

Vehicles and machinery

Serrated tussock seed heads can become caught in vehicles, machinery, tractors, implements, spray units, mowers and slashers, which can spread seed long distances from the original infestation. For example, slashing during the flowering period is a major method of seed spread and contamination.

Seed can also be picked up in mud by machinery and vehicles tyres.

Animals

Livestock will generally avoid eating serrated tussock; however, if they do graze on it while in seed, the animal can spread seed through their droppings. Seed survives passage through the gut of ruminant animals and can remain in the gut for up to 10 days, making it possible for serrated tussock to be spread long distances by livestock.

The awns and soft sticky hairs of the serrated tussock seed make it capable of attaching to the fleece or fur of stock and other animals, and may also be picked up in mud on the hooves of livestock.

Birds have been seen to use serrated tussock seed heads as nesting material. Rabbits, pigs and wombats can be a particular problem as they can create bare patches of ground making it easier for serrated tussock to establish.



Chelsea Wardrope

Animals grazing on serrated tussock may transport seed.

Stock feed and produce

Serrated tussock seed can be a contaminant of crops, hay, silage, grain or seed. Movement and use of contaminated produce can lead to the development of new infestations, often long distances from the original source. This risk is increased during drought conditions when lower quality hay, seed and grain is sold, bought and transported extensively across the country.

Weeds often accumulate in areas where things are stockpiled. Serrated tussock has been known to be moved in firewood and railway sleepers.



Charles Grech

Serrated tussock growing where hay is stored could potentially contaminate produce.

Soil

As serrated tussock develops a substantial seed bank, any movement of soil from an infested area is likely to transport seed and create new infestations. Potential movement of seed can occur via activities such as road works, landscaping or building activities.

Water

Rivers, creeks and water channels can transport serrated tussock seed downstream from the original infestation. In particular, flood waters are known to move seed downstream to new locations.



DPI Victoria

Serrated tussock growing near water can spread seed downstream.

Identification

The common name of 'serrated tussock' is used to describe the plant's serrated leaves and tussock growth habit. While it does have a 'serrated' feel to the leaves, this term can be misleading as many other similar tussock grasses have serrated leaves. Other common names include Yass River tussock which refers to where it was first identified in NSW and nassella tussock (South Africa and New Zealand).

Identification of grasses can be difficult, especially when the seed head is not present. Serrated tussock can be confused with a number of native tussock grasses as well as other introduced *Nassella* species.

This part of the manual aims to assist with the correct identification of serrated tussock when in seed and when not in seed, and highlights the differences between other similar grasses. Serrated tussock is easy to misidentify and if in doubt seek expert advice.

Serrated tussock leaves roll smoothly like a needle when rolled between the index finger and thumb. Native grasses will feel like they have flat edges.

Identifying serrated tussock in seed

Serrated tussock can be identified when in seed by its seed head and seed. The seed of serrated tussock is unlike the seed of any other tussock grass that it may be confused with.

Flowering stems and seed heads

The flowering stem of serrated tussock can be up to 95 cm, twice as long as the leaves. Initially erect, the seed head will weep over the entire plant to touch the ground once the seed is ripe.

The seed head is an open panicle (multi-branched stem) up to 35 cm long. It has two or three branches at each junction and one seed at the end of each branch.

The seed head is purple soon after flowering and then turns a golden brown when the seed has matured. Once the seed has ripened, the entire flowering stem will break off from the base of the plant.

Key identifying features of serrated tussock:

- tussocky grass to 60 cm tall
- thin, tightly rolled, hairless leaves with very fine serrations
- white hairless ligule
- white swollen leaf bases
- purple tinge to flower heads, later turning golden as the seeds ripen
- weeping flower heads that break off at maturity
- difficult to pull from the ground, even when small.



Bronwen Wicks

A paddock of serrated tussock in flower—note the purple tinge to the flower heads.



Charles Grech

Seeds are a distinctive purple colour.

Seeds

Each seed is 1.5–2 mm long and enclosed in two reddish brown or purple bracts (glumes), 6–10 mm long which taper gradually to a point. The seed has a tuft of short white silky hairs at one end and a long, twisted awn at the other end.

The awn is attached to the seed off centre and its length varies. In NSW, ACT and Tasmania, the awn length is about 25 mm long. In Victoria the awn length can be up to 35 mm long.

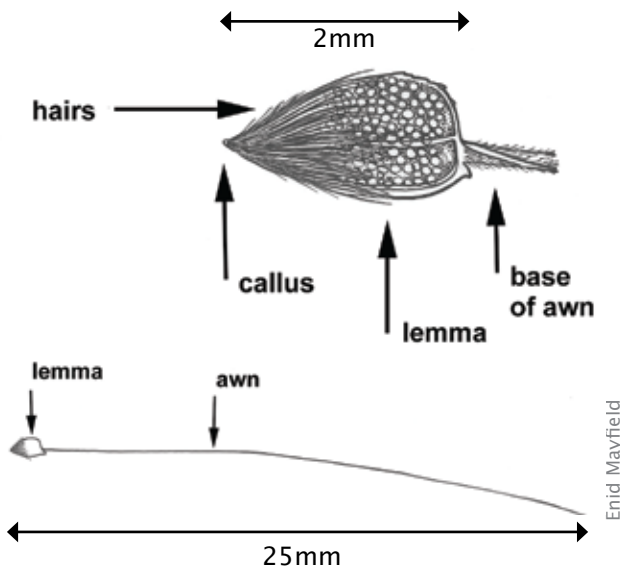


Figure 3. Seed and awn of serrated tussock.

Identifying serrated tussock when not in seed

When not in seed, serrated tussock can best be identified by its:

- colour
- leaves
- ligule.

Colour

Serrated tussock is a plant that changes colour with the seasons.

Plants appear purple when flowering in late spring/early summer. Once the seed ripens in late summer, flower heads change to a golden brown colour with a light green tussock base.

Plants remain green during summer, when other grasses have usually browned off. Some older leaves may die and remain beige on the plant for several years.

In frost prone areas, the tussocks are bleached a golden yellow colour by frost during late autumn and winter.

Leaf bases are always white and tussocks are a light green colour when recovering from burning or slashing.



Malcolm Campbell

Frost will bleach the leaves of serrated tussock plants.



Charles Grech

Young serrated tussock plants are bright green.



David McLaren

Light green serrated tussock plants may be easier to spot when desirable plants have browned off.



Simon Bonwick

Seeds of serrated tussock are purple in colour, giving the plant a purple appearance when in flower.



Graeme Prichard

Serrated tussock showing white bases and old leaves with fawn coloured tips.



Michael Michelmore

Mature seed heads turn a golden brown/purple colour and can arch over touching the ground.



Charles Grech

Dead serrated tussock next to native poa tussock. Correct identification is critical.



Graeme Prichard

Serrated tussock seedling showing large, extensive, fibrous root system.



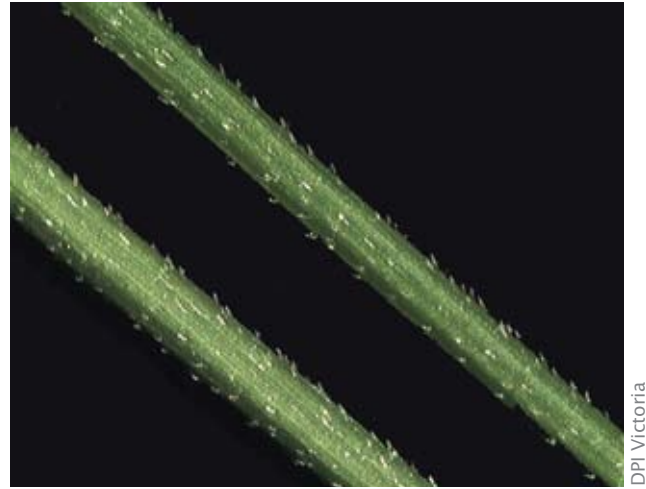
Graeme Prichard

Serrated tussock seedlings in an over-grazed paddock.

Leaves

Numerous thin leaves up to 50 cm long emerge from the base to form a large tussock. They are tightly rolled and are finely serrated with white bases. These fine serrations can be felt if the finger and thumb are carefully pulled along the leaves from the tip towards the base in a downwards motion.

When serrated tussock leaves are rolled between the index finger and thumb, they roll smoothly like a needle. This differentiates them from some similar native grass species, which feel like they have flat edges.



Fine serrations of serrated tussock leaf.

DPI Victoria

What is a ligule?

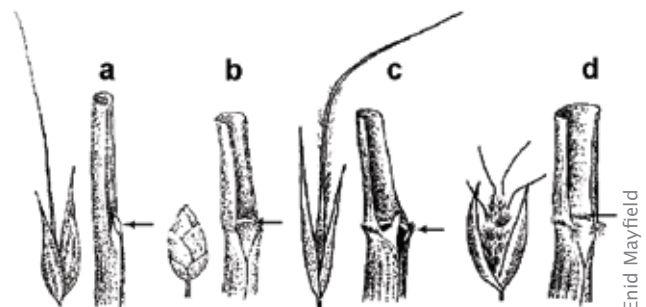
A ligule is a membranous or hairy appendage that occurs at the junction where the leaf separates from the stem. To find the ligule, trace down a leaf to its junction with the stem. Carefully separate and bend the leaf back. If the grass has a ligule is a small, membranous or hairy flap that protrudes.

The ligule of serrated tussock is continuous with the leaf sheath, is small (1 mm long), white, has a rounded tip and is never hairy. Most grasses that are confused with serrated tussock have hairy ligules.



Ligule of serrated tussock.

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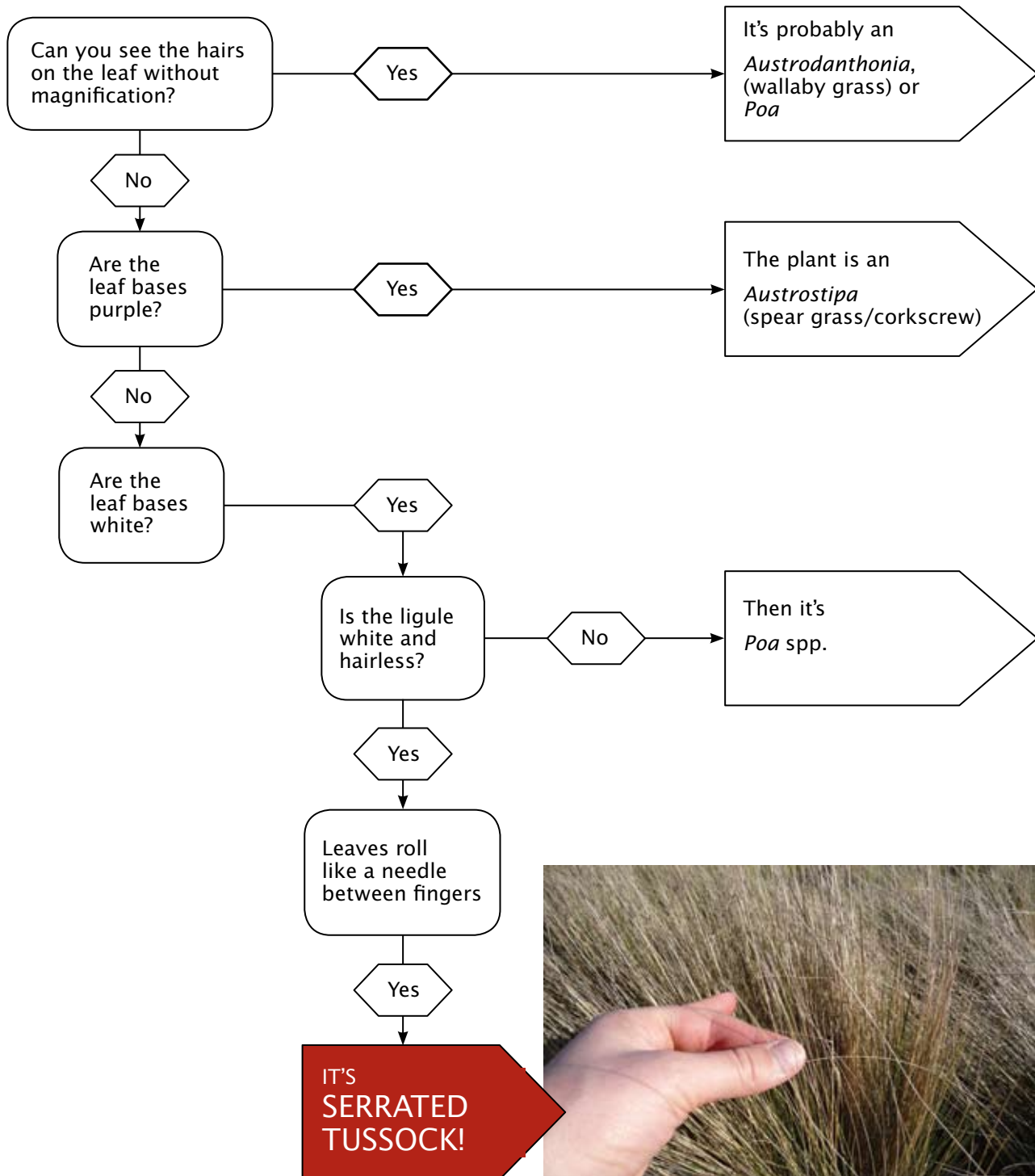
Enid Mayfield

- Seed with glumes attached, and section of leaf blade and leaf sheath showing ligule (arrowed):
- a. serrated tussock;
 - b. silver tussock, *Poa labillardierei*;
 - c. spear grass, *Austrostipa* sp.;
 - d. wallaby grass, *Austrodanthonia* sp.

How to distinguish serrated tussock from similar native grasses

Serrated tussock is very similar in appearance to many native grasses, including tussock grass (*Poa labillardierei*), snowgrass (*Poa sieberiana*), spear grass (*Austrostipa* spp.) and wallaby grass

(*Austrodanthonia* spp.). To determine whether or not you have serrated tussock, the following diagram can be used.



Chelsea Wardrope

Diagram: Andrena Jones
Source: Linda Ayres



Meredith Mitchell



Wallaby grass (*Austrodanthonia* spp.).
 Leaf blade is folded in the bud and there are parallel veins of thickening on the leaf blade. Distinguishing features: fine leaves; grows all year; hairy ligules; seedhead has a fluffy appearance at maturity.



Meredith Mitchell



Meredith Mitchell



Spear grass (*Austrostipa* spp.).
 A coarse-tufted grass that remains green all year. Distinguishing features: leaves are rough to tough and are covered in miniature hairs; the seed has a long awn with a corkscrew twist (up to 6 cm long).

Poa labillardieri (poa/silver tussock)
 Seedheads are open and pyramid shape. Distinguishing features: channelled leaf blade; grows on lower slopes and valley floors. *Poa sieberiana* (snow grass) - Leaves are usually inrolled. Seedhead is pyramid shaped. Distinguishing features: grey-green leaves; grows on mid slopes to ridges-areas that are well drained.

Poa/silver tussock (*Poa labillardieri*).



Themeda triandra (kangaroo grass) is one of Australia's most important native grasses and commonly overlaps its distribution with serrated tussock.

Kangaroo grass (*Themeda triandra*).

Distinguishing features: leaf blades folded in the bud; older leaves have a red/brown tinge; seeds are very shiny dark brown with a sharp base collar of hairs; seedheads are 30-50 cm long, rusty-red colour in summer, and on stems with dark nodes.

Differentiating serrated tussock from other *Nassella* species

Serrated tussock (*Nassella trichotoma*) is one of seven *Nassella* grasses that occur in Australia. Others include Chilean needle grass (*N. neesiana*) also a Weed of National Significance, Mexican feather grass (*N. tenuissima*), cane needle grass (*N. hyalina*), Texas needle grass (*N. leucotricha*), lobed needle grass (*N. charruana*) and short-spined needle grass (*N. megapotamia*).

Other *Nassella* species can be differentiated by seed size or the corona around the seed. To distinguish the seed of serrated tussock, compare the illustrations in Figure 4.

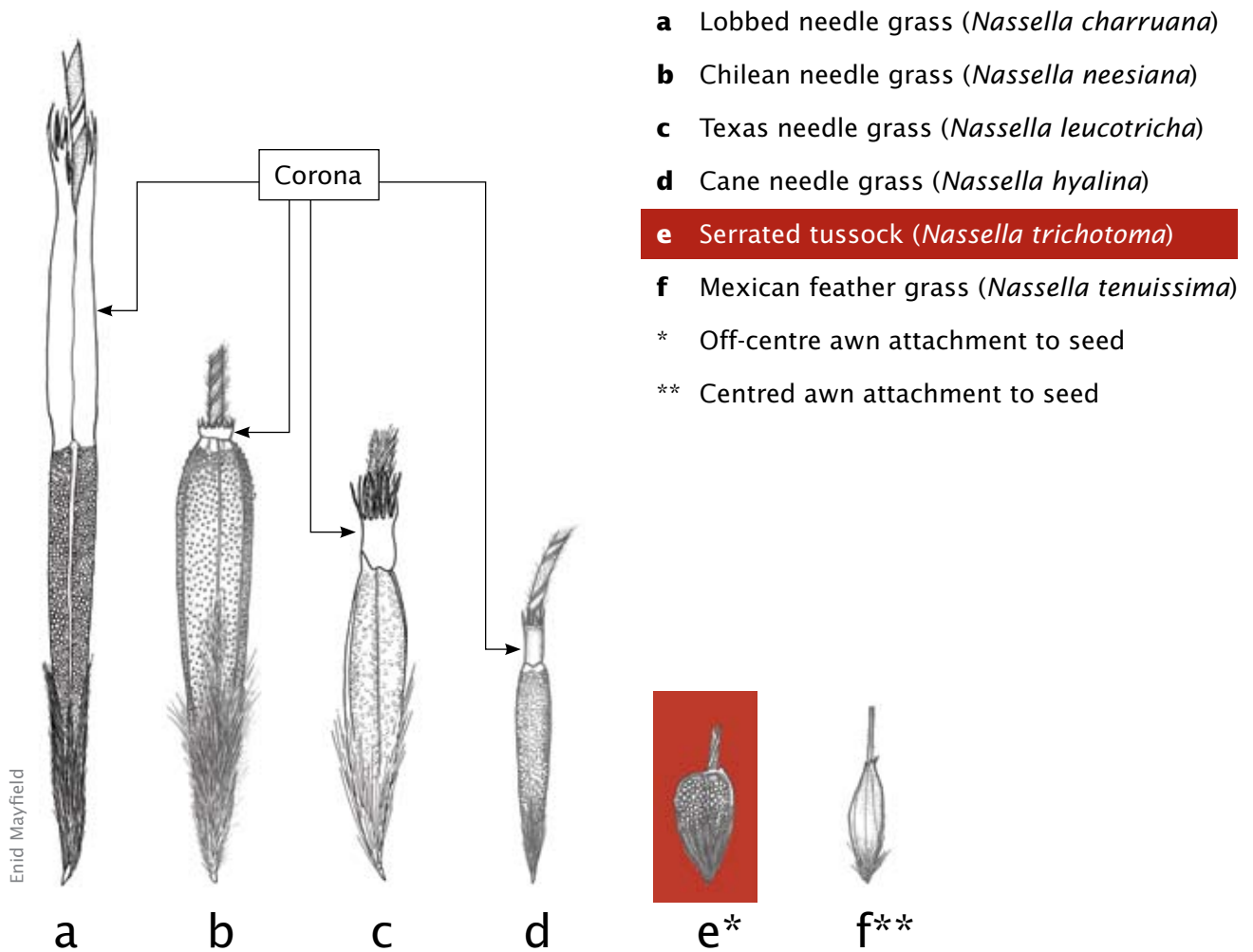


Figure 4: Features to distinguish serrated tussock seed from other *Nassella* grasses.
 Drawings: Enid Mayfield

Lobbed needle grass (*N. charruana*) has a 4–6 mm long whitish, papery corona, seed is 8 mm long and slender.



Chilean needle grass (*N. neesiana*) has a crown-like corona with thick, tooth-like hairs (less than 1.5 mm), long panicle seed 6–10 mm and awns 40–85 mm long.





David McLaren

Texas needle grass (*N. leucotricha*) has long thin hairs (3 mm) on the corona, seed 6–10 mm long, awn 35–60 mm long and bent twice.



DPI Victoria

Cane needle grass (*N. hyalina*), has a larger seed (3.5–6 mm), corona has long thin hairs.



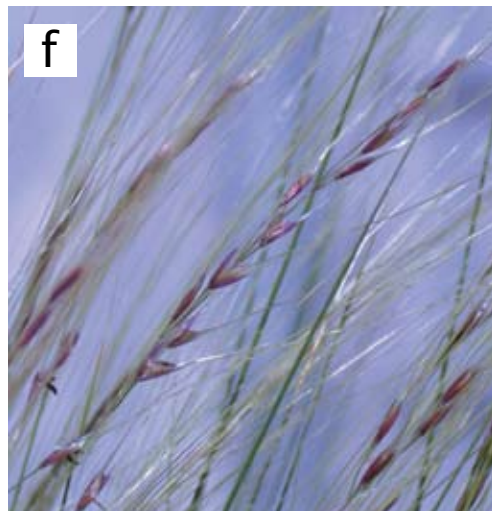
DPI Victoria

Serrated tussock (*N. trichotoma*) has a small seed (1–2 mm), corona not visible to naked eye, awns up to 35 mm long and attached off centre.



Steve Taylor

Mexican feather grass (*N. tenuissima*) has a similar sized seed (2–4 mm) and longer awn (50–90 mm) that attaches centrally to the seed.



Alan Maguire

Section 2

Integrated weed management (IWM)

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What is integrated weed management?

Integrated weed management (IWM) is a term used to describe the long term management of a weed using a combination of different management and control techniques. An IWM approach will be tailored for a given weed based on its ecology, density and the land-use situation in which it occurs.

Weed management techniques include physical/mechanical, chemical, biological and cultural or social control practices. All of these techniques may be part of an IWM system—it's unlikely that a single control measure on its own will be effective over the long-term.

Simple weed management generally treats only the symptoms of a weed infestation, typically by using direct treatments to kill weeds. In contrast, IWM attempts to address the underlying causes of a weed infestation, rather than just focusing on controlling visible weeds. It does this by targeting the different stages of the weed's lifecycle and undertaking measures that will prevent weed reproduction, reduce weed emergence, promote seed bank depletion and minimise weed competition with desirable vegetation (Trotter 2007).



DPI Victoria

Learn to correctly identify serrated tussock.

IWM is a critical approach for the successful long-term control of serrated tussock.

Although looking at the fundamental causes of weed invasion and persistence is more demanding than simply spraying weeds, the rewards are far greater and are worth the effort. Over the long-term, IWM should lead to greater success in meeting weed management objectives

An IWM approach requires the development of a plan that will aim to achieve weed control via the most economic and effective means, while minimising any unfavourable impacts on non-target plants and animals.

IWM is a critical approach for the successful long-term control of serrated tussock. One of the many benefits of IWM is that by using a range of control methods over time, and not relying solely on chemical control, the risk of weeds developing herbicide resistance is greatly reduced.

Successful weed management will include a combination of the following:

- prevention of weed invasion and spread
- correct identification and knowledge of the weed's lifecycle
- mapping, recording and monitoring weed populations
- control decisions based on best available knowledge, including cost and short and long-term environmental impact
- a control strategy or plan that uses a combination of methods to reduce the weed population
- control and management actions incorporated into daily property activities
- monitor and evaluate the effectiveness of management decisions
- follow up control and management measures.

Training in correct identification of serrated tussock is an important step in the management process.

Serrated tussock and integrated weed management

Serrated tussock IWM aims to achieve long term control by actively targeting the plant's vulnerable ecological features and by reducing its ability to continue to spread. The key principles of IWM to keep in mind are:

- early intervention
- prevent establishment & spread
- develop a plan utilising appropriate management tactics.

Serrated tussock plants are most vulnerable as young seedlings and preventing seed-set in adult plants stops the formation of tens of thousands of seeds. Therefore the most effective techniques will target these features, for example, maintaining ground cover for competition and chipping prior to flowering.

Basic principles to consider for the integrated management of serrated tussock are:

Seed bank management

- Reduce the amount of seed going into the seed bank.
- Minimise disturbance to the seed bank, which may reduce the germination rates of serrated tussock seed.

Target young serrated tussock seedlings

- Seedlings are small, slow growing and vulnerable to competition.
- Reduce seedling survival by minimising bare ground cover and increasing the level of desirable vegetation.

Prevent seed-set in adult tussock plants

- Reduce the occurrence or severity of seed rain into your own and neighbouring properties.
- Reduce new seed being added to the seed bank.
- Serrated tussock seed bank will be depleted over time.

Prevent/reduce weed seed spread

- Use prevention strategies such as mesh fencing, shelterbelts and vehicle hygiene in managing serrated tussock.
- Regularly monitor areas at high risk of invasion, such as fence lines.
- Quickly eradicate new, small or outlying infestations.

(*'New seed, 10 years of weed'*
(Bathurst workshop).)

Actively increase ground cover and competition

- Ensure there is always competition for young, vulnerable serrated tussock seedlings.
- Prevent initial establishment of tussock populations. A good vigorous pasture or grassland cover is less likely to be infested by serrated tussock.

Regularly monitor, follow up and review treatments

- Make an integrated weed management plan. Diligently implement the plan, emphasising diverse treatments that kill adult plants or stop them from setting seed.
- Incorporate serrated tussock management into daily property activities.

Factors critical for success

- Begin when infestations are small and manageable or during periods of drought. Letting it 'get away' will increase the time and expense of getting serrated tussock back under control.
- Rotationally graze and manage vegetation levels accordingly—overgrazing and set stocking can leave bare patches of ground and provide room for tussock to re-emerge.
- Requires a long term commitment. This means any paddock where control has been undertaken needs to be followed up every year after initial treatment.



Michael Michelmore

Target seedlings for control.

When deciding which particular treatment or combination of treatments to use, always choose the treatment that will cause least amount of damage to the desirable vegetation and the environment. More information on the control and management of serrated tussock is outlined in the following chapters.

Herbicide resistance

What is herbicide resistance?

Herbicide resistance is the ability of a plant to survive and reproduce following exposure to a dose of herbicide that would normally be lethal. In a plant, resistance may occur naturally due to selection or it may be induced through techniques such as genetic engineering.

Resistance occurs in plants as a result of random and infrequent mutations. Through selection, susceptible plants are killed while herbicide resistant plants survive to reproduce without the competition from susceptible plants. If the herbicide treatment is repeated, resistant plants successfully reproduce and become dominant in the population. The appearance of herbicide resistance in a plant population is an example of rapid weed evolution.

Serrated tussock resistance to flupropanate

Flupropanate is a soil active herbicide that has residual activity and can prevent serrated tussock from regrowing for three to five years (Campbell and Vere 1995). It is classified as a Group J herbicide that inhibits plant lipid synthesis and is regarded as a moderate risk herbicide for resistance (Croplife Australia 2007).

Herbicides that have long soil residual and season-long control of germinating weeds, like flupropanate, characteristically increase selection pressure and the likelihood of resistance (Figure 5).

There are now three separate confirmed instances of serrated tussock populations resistant to flupropanate in NSW and Victoria. The continued use of flupropanate over a 15–20 year period is the most likely cause of these resistant strains developing (McLaren *et al.* 2008).

Flupropanate – one application provides soil residual control of germinating serrated tussock for 3–5 years.

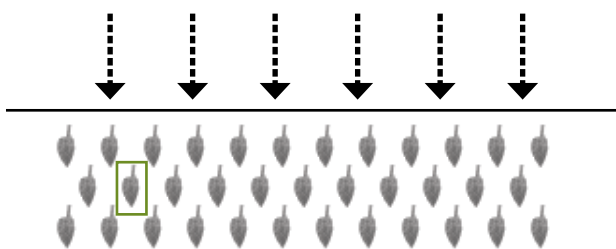


Figure 5: Herbicides that have long soil residual and season-long control of germinating weeds characteristically increase selection pressure and the likelihood of resistance.

Serrated tussock reproduction and implications for serrated tussock resistance

Serrated tussock reproduces by producing seed that can travel long distance (see page 10). Research has shown that 85–90% of serrated tussock flowers don't open at flowering. Instead they exchange pollen within the unopened flower and produce a clone of the parent plant. This means that a resistant plant will produce at least 85–90% resistant seed.

Research has also shown that pollen from a resistant serrated tussock plant can create resistant seeds in a wild type susceptible serrated tussock plant, but at very low ratios (1:29). The good news is that only 10–15% of serrated tussock seeds are open for pollination, resulting in smaller opportunities for cross fertilisation and production of resistant seeds. However, the prolific seeding capacities of serrated tussock does make this possible and pollen induced resistance has been recorded in Victoria.

How far can a serrated tussock pollen grain travel? At this stage it is not known; however, genetically marked pollen from the perennial grass, brown top bent grass, has been recorded fertilising wild plants 21 km from its source.

The long term implications of serrated tussock herbicide resistance are:

- its increased dominance as a weed
- increased costs for land managers
- more herbicide usage
- higher environmental pollution as a consequence.

It is now appropriate to undertake serrated tussock flupropanate resistance paddock surveys around the properties identified, to determine the extent of resistance and take appropriate remedial actions.

There is also growing global concern regarding resistance to glyphosate. Luckily at this stage there have been no reported instances of glyphosate resistance in serrated tussock.

Reduce the risk of herbicide resistance by rotating chemicals with different modes of actions and use IWM.

Ways to avoid herbicide resistance

1. Most importantly—do not rely solely on the use of chemicals for control.
2. Use immediate acting or short residual herbicides whenever possible. Use long term residual herbicides (like flupropanate) wisely and not continuously on the same field.
3. Integrate herbicide use with other weed control strategies (practice IWM).
4. Always apply herbicides according to label directions.
5. Regularly rotate the herbicide types used with different modes of action. For example, Group J (flupropanate) or Group M (glyphosate).
6. Always monitor and follow up control on any re-growing serrated tussock plants.
7. Check sprayed areas for resistant plants. If there are any plants that have not been affected by the herbicide application, always investigate the reason why it happened.
8. Practice good sanitation practices to reduce movement of weed seed.
9. Do not let any serrated tussock plant set seed.



James Browning

Population of serrated tussock resistant to flupropanate.

Managing flupropanate resistance

In 2007 a property near Armidale in the New England Tablelands of NSW was identified as having a population of serrated tussock resistant to the herbicide, flupropanate. Prior to this, the property had relied heavily on broadacre spray applications of flupropanate in their serrated tussock control program.

The resistant serrated tussock currently covers about 20 ha of land and is the target of a control program. The affected area has been cultivated and a cover crop of oats has been sown with pasture underneath.

Spraying with flupropanate has been disbanded and spot spraying program using glyphosate is being used instead. Strict hygiene protocols are being employed to prevent serrated tussock seed leaving the property from stock, vehicles or machinery. While this option is time consuming and may cause some pasture damage, there is little else they can do. There is no short-term solution and ongoing resources are required to control the population of resistant serrated tussock.

At this stage it is too early to tell how successful the cropping phase will be; however, previous pasture renovation they have undertaken on the property has worked well with the property now at a spot spray programme that is progressively reducing level.



James Browning

The same property after cropping and pasture renovations.

Follow up

Once one serrated tussock plant is killed, there are many seeds in the seed bank waiting to germinate and grow in its place. It is not possible to treat an area once and then forget about it. For serious serrated tussock control, follow up will be an integral part of the weed management plan.

Where control has been unsuccessful or serrated tussock is beginning to re-emerge, further control will be required. The type of control required for follow up will depend upon the situation and the density of serrated tussock.

After any treatment, re-establishment of serrated tussock may occur as a result of:

Inappropriate use of treatments

- Herbicide applied at the wrong time of year, at the wrong rates or using equipment that has not been calibrated correctly.
- Many plants are missed or treatments are ineffectively applied.
- Serrated tussock population is resistant to flupropanate.
- Slashing at inappropriate times of the year. For example, when in flower or seeding, may increase the spread of tussock.
- Direct drilling crops and pasture without thorough preparation of the seed bed, such as using glyphosate or correcting soil fertility and pH.
- Using inappropriate control methods for the situation.



Luke Pope

Over-spray of herbicide can leave areas of bare ground.

No competition

- The cover of desirable vegetation is low, with large areas of bare ground.
- There is a large seed bank in the soil.
- Chipping has created large bare areas that has not had seed and fertiliser added.
- Removal of vegetation and/or trees.
- The control method previously used caused damage to existing desirable vegetation—killing existing perennial grasses and removing competition for serrated tussock seedlings.

Climate

- Environmental conditions such as drought may act as a contributing factor to unsuccessful control.
- Insufficient rainfall to promote the growth and development of an improved pasture.
- The land is naturally unproductive, having low rainfall or poor soil.

No follow up

- Failure to regularly follow up control measures and address the infestation at the seedling stage.

Preventing seed spread

- There is a large population of serrated tussock up-wind.
- Failure to use correct hygiene measures for equipment and stock can spread seeds.

Limited knowledge

- Misidentification or late identification of serrated tussock—leading to late management.
- Absenteeism on commercial land where it has been subdivided and neglected.

*'Failure to follow up is failure to farm for the future'
(Cooma workshop).*

*'Follow up, follow up, follow up'
(Goulburn workshop).*

*'If you don't follow up, then you are wasting your money'
(Bathurst workshop).*

The need for broader community and/or catchment planning

Working together in your region is essential for the successful management of serrated tussock. Due to the tussock's unique feature of producing tens of thousands of small, viable, wind dispersed seeds; there is always the risk that seed can be blown in from a neighbouring property. A way of managing this risk is to work with your neighbours and community to coordinate serrated tussock control in your area.

This can mean talking to and raising awareness of the need to coordinate the control of serrated tussock with your local Landcare coordinator or Landcare group, the catchment management authority, local council, and Department of Primary Industries in your region.

Suggestions for starting local community management groups are at the end of this chapter.

*'No landowner on their own
can achieve results'
(Canberra workshop).*



Byron Stein

A coordinated planned approach can make a difference.

Developing an integrated weed plan

An integrated weed management plan must be individual, practical, economically sound and flexible. Individuality is necessary within a plan because the problems and possibilities differ from property to property, with soils, land-use and climate. A plan should always allow adaptation from year to year as situations change and new technology becomes available.

When developing a weed management plan, do not treat one weed in isolation—think of the property as a whole system with many parts.

When selecting a management program, consider the impacts that a control technique will have on the weed, the desirable vegetation and the production system.

An integrated serrated tussock management program has four steps:

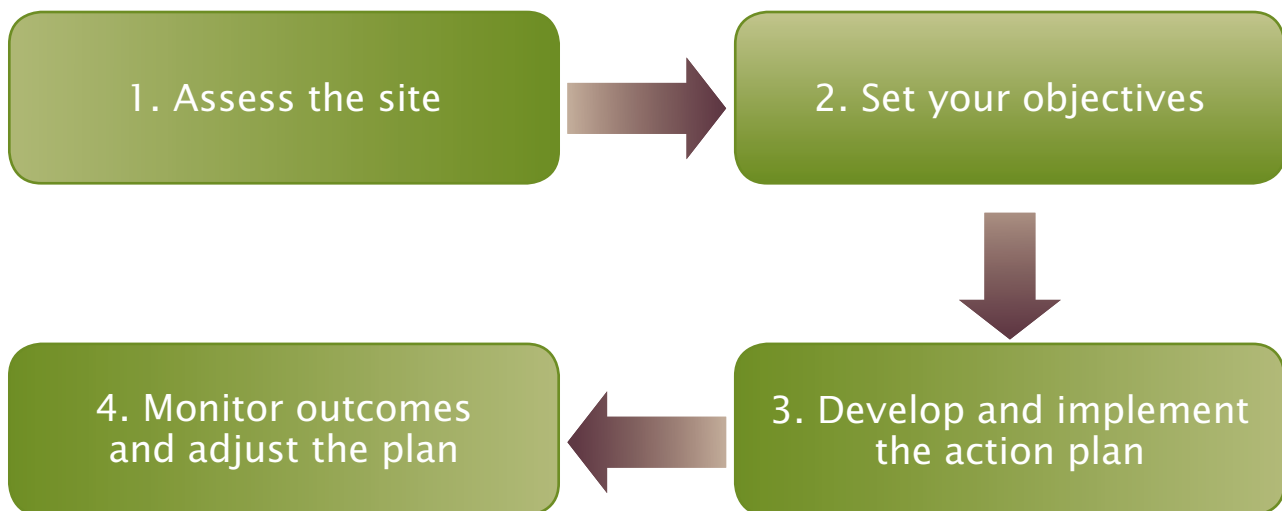


Figure 6: Four steps to making an integrated management plan.

This section outlines what to consider at each of these steps.

How much detail and information do I need in my plan?

Where large infestations have developed, serrated tussock management can become complex. Successful management relies on a good plan and a suitable recording system.

Where a land manager works alone or where infestations are small, a simple recording system is encouraged. A hand-drawn property plan is a useful tool to continuously add notes and plan treatments. Where the situation is more complex, or a land manager needs to share the information with others, a more thorough recording and planning system may be required.

Set targets for your weed management and develop a plan to help you achieve them (Canberra workshop).

'You've got to keep on controlling it.' Integrated weed management is an ongoing process. There are farmers who spot spray 1000 acre properties and make it a priority every year (Hobart workshop).

Step 1: Assess the site

A site assessment is essential to know what you are dealing with and the extent and density of serrated tussock (and other weeds) on your property. Many tasks in the site assessment may be easier if you can get assistance from appropriate experts, such as private consultants, district agronomists, Landcare coordinators, government agency or catchment management authority staff.

An essential skill in making a site assessment is being able to correctly identify serrated tussock, from other similar grasses, through different stages of its lifecycle and as it changes through the seasons. Section 1 provides basic information on identification, but this may need to be reinforced with hands on experience, perhaps with an extension professional, as grasses can be extremely difficult to identify.

Mapping weed infestations

Mapping is a tool that can help you to plan ahead and to communicate your weed control activities and their progress with other interested parties, such as staff, family, contractors, neighbours or Noxious Weed Authorities. It is also, importantly, a means to review progress, measure success and adapt your activities to changing conditions.

A large-scale topographic map or an aerial photograph is a useful base map for recording weed infestations and other features that will impact on weed management. A weed map does not need to be elaborate, it can be simple and hand-drawn, but importantly it needs to be clearly labelled so that it can be adapted from year to year.

Serrated tussock control is a long process and will not happen in the short-term.

Allocate a reasonable timeframe for the control program.

When mapping serrated tussock infestations record information such as:

- property boundaries, paddocks, natural features and improvements
- all vegetation, both beneficial pasture species and weeds, present in the paddock. Get to know what plants are in the paddock
- different vegetation types and land classes within the property, for example, improved pasture grazing land, non-arable steep rocky slopes or native pasture for grazing
- the location, size and density of the serrated tussock infestations
- consider documenting risks or issues, such as accessibility and assets of agricultural, environmental and cultural value.

Do you need to map serrated tussock or improve existing maps?

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

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

The information obtained from the map will then allow you to:

- accurately target and prioritise weed control activities
- locate areas at high risk of invasion such as fence lines, gullies, roadsides, riverbanks, vehicle tracks and clean-down areas
- budget costs and time required to implement control techniques
- monitor how well control methods are working.

Keeping a photographic record

Taking a photo is an excellent way to keep a record and can be used for annual monitoring. This is best done by clearly marking a 'photo point'. For example, a picket or tin lid fixed securely into the ground, and then mark the position on your map. Remember to always face the same direction when taking photos.

Take photos at different times of the year; before and after control treatments, and continue to do this on a yearly basis. This tool assists with monitoring as it gives a visual representation of what is happening in the paddock and if any change has occurred as a result of control.

A number of 'photo points' can be made throughout a property.

Estimate density

Estimating the density of serrated tussock infestations is important to help choose appropriate control methods and to prioritise areas for treatment. Serrated tussock is likely to occur as 'patches' within a paddock or landscape and it may be difficult to determine an overall density rating.

Also look at the ratio of adult tussocks to juvenile plants or seedlings and whether there is evidence of mature seed heads. This will help provide information on the age of the infestation and whether it is well established or a relatively recent incursion—which in turn helps identify the best mix of control measures.

*Mapping is important for planning control strategies and enables you to specifically target 'hot spots' of tussock
(Canberra workshop).*

Visual assessment of density

Visual assessment is a simple way to determine weed density. It is quick and easy and useful for smaller sites and most species, but can be subjective. Figure 7 may help determine the percentage cover of serrated tussock. Note that cover can appear as scattered plants throughout a paddock or as a clump. A cover of 50% can appear very dense.

The density of the infestation will help determine which management techniques to use.

- A density of less than 10% ground cover is considered a light, scattered infestation.
- Density of 10–30% ground cover is a medium level infestation.
- Density of greater than 30% ground cover is considered a high level infestation.

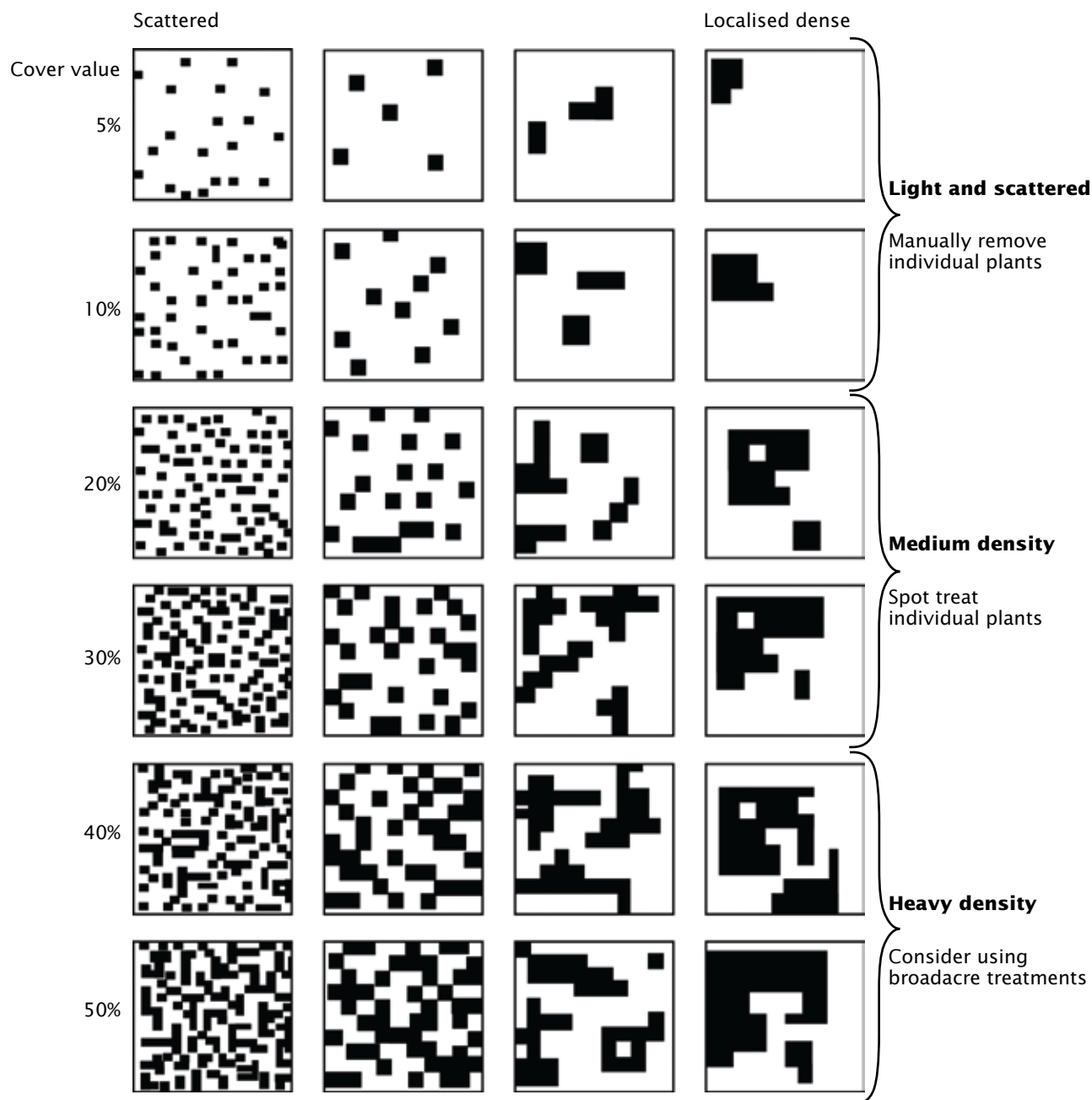


Figure 7: A guide to visually estimate serrated tussock as a percentage of ground cover.

(Source: Lane, D, Jugovic, J, Murphy, G. and Backholer, J. (1988) *Pest Management Information System Manual*. Land Protection Division, Department of Conservation, Forests and Lands, Victoria)

Step 2: Set your objectives

Objectives are statements of the intended outcome you want to achieve over a certain time frame and can be measured. They may have a short, medium or long-term time line and are designed to work together in an integrated plan. It may be useful to include a realistic number of short-term goals that can be practically achieved, to give a sense of accomplishment. Too many long-term complex objectives can sometimes lead to exhaustion and disillusionment.

Objectives can be applied at any scale, from one paddock within a property to a whole farm, region or landscape. Multiple objectives may be required if the situation is complex.

Objectives set the direction you wish to move in and will help guide your decisions on serrated tussock control strategies and drive your on-ground activities.

Having a positive attitude and setting priorities to control tussock is crucial.

Examples of some objectives are:

- Short-term – stop serrated tussock from going to seed: to reduce the seed levels in the soil seed bank. Work together with neighbours to form a district plan to tackle the serrated tussock problem.
- Medium-term – decrease the level of bare ground and increase the level of desirable pasture species: to minimise serrated tussock invasion and to support livestock production.
- Long-term – restore steep inaccessible areas to native vegetation: remove the ‘mother-lode’ so land is no longer a seed source into productive land or neighbouring properties.

*‘Never pass a tussock without action.’
Be proactive in your management of tussock (Goulburn workshop).*

‘Don’t bite off more than you can manage.’ Maximise the resources and land capacity you have available and be realistic with what is achievable (Goulburn workshop).

Step 3: Develop and implement the action plan

Developing an action plan is the critical step which brings together your objectives, the physical environment and suitable control techniques. It is a complex process to draw these strands together and develop an action plan for effective long-term serrated tussock control. Seek assistance from professionals or others who’ve been through this process—some extra help may be all that is needed to get this process moving.

As you develop your action plan it can be useful to move through different scales of information or viewpoints—from the plant, the paddock, a group of paddocks, the whole farm, the sub-catchment and region or catchment. Some control techniques or preventive measures may be more appropriate at the whole farm scale, rather than the paddock. For example, providing protection for the whole enterprise, not just the paddock.

Look for synergies and multipurpose control activities, where one action can have several functions. For example, shelterbelt tree planting can provide a wind shelter for grazing animals, habitat for native animals, soil protection, as well as reduce serrated tussock seed being carried in on the wind.

When developing the action plan it is important to:

1. Work to integrate serrated tussock activities into your everyday farm management—take a mattock and a small spray pack out with you when conducting regular property inspections.
2. Mark key serrated tussock activities on your farm calendar.
3. Get to know the lifecycle of serrated tussock and desirable pasture species. This will determine when activities need to be conducted and will help when planning the control calendar. Take note of when flowering and seed development occurs.

Sometimes it can be difficult to know where to start.

Prioritising areas for serrated tussock control

The key principles to consider when identifying areas or actions for serrated tussock control are:

Prevention: where no serrated tussock exists, prevent it from entering the land. Prioritise hygiene practices and maintain a healthy ground cover of vegetation.

Eradication: where early stage invasion or small isolated infestations exist, high priority should be given to eradication.

Reduction or containment: where serrated tussock is established and/or widespread, it may be unrealistic to expect to immediately eradicate the weed. In these situations it will be beneficial to limit the impact of serrated tussock, by progressively decreasing the infestation size and to keep it from spreading further. All efforts need to comply with local legal requirements.

‘Control light infestations, contain the heavy’ (Bathurst workshop).

Focus tussock control on the most productive areas, to ensure income. After the productive land is controlled, draw your attention on less productive areas. (Canberra workshop)

Consider high priority areas as follows:

- 1. New, small or outlying infestations** should be eradicated first to stop a seed bank from developing and reduce the likelihood of a large infestation developing.
- 2. Areas with high risk of spread**, such as stockyards; humps between wheel ruts; hill tops, steep, rocky or inaccessible areas; fence lines; creek and riverbanks; and roadsides should all be controlled as a high priority, to limit further spread and reduce the chance of new infestations developing.
- 3. High value assets** where infestations are established, including the most productive pasture, the highest value native grasslands and sites of community or cultural importance.

Don't forget to include property hygiene practices in the weed management plan.

Determine control methods

Identify the most appropriate combination of methods to control serrated tussock for your situation. Sections 3 and 4 should be able to assist you with this.

Consider the effectiveness of each control method at different times of the year and balance this with the time and resources (equipment, labour and finances) available. Remember to include integrated weed management principles into your plan.

Once objectives and a plan of action has been decided:

- allocate time specifically for serrated tussock control
- allocate responsibility for actions
- schedule activities on a calendar, including all property activities such as shearing, drenching, marking—depending on the farming enterprise
- include some small tasks that can easily be completed to generate a feeling of accomplishment
- get started.

An example of questions you can ask yourself include:

- o *What financial sources do I have to fund my management?*
- o *What plant species are currently present?*
- o *What seed sources do I have available for re-vegetation? (Cooma workshop)*

Do your weed management plan online

The Queensland Department of Natural Resources and Water has developed a Property Pest Management Plan (PPMP) kit. The kit contains guidelines on how to prepare a PPMP and practical worksheets to help develop one for your property. The kit is available online at www.nrw.qld.gov.au/oneplan.

Step 4: Monitor outcomes and adjust your plan

Monitoring is an essential part of any good management program. During implementation of your program, frequently monitor and review your program. Points to consider include: Have control works been successful? What follow up action is required? What will be required next year?

- After implementing your strategy, return to the site in 3–6 months time and take photos. Assess before and after shots and chip out any small plants (Bathurst workshop).
- Regularly check all sites where control activities have taken place, monitor paddocks for current, arising and potential infestations.
- Timing can have an influence over the visibility of serrated tussock. Monitor late summer when it is exposed to dry conditions and still green in appearance (Hobart workshop).
- Record the success of control activities and use this to review and adjust your plan.
- Take notes on what works and what doesn't.
- Record progress in a site diary, on maps, information sheets, or with photo points.
- Record changes in serrated tussock density or percentage cover.

Doing this will build a picture of what is happening over time, enabling you to identify new issues to plan for next year and, if necessary, demonstrate progress to your group, funding body or weed authority.

Adjust your weed management plan based on the information collected and conduct follow up treatments where necessary.

Source: Module 1: *Developing and implementing a weed management plan* in: CRC for Australian Weed Management (2004). *Introductory weed management manual*. Department of the Environment and Heritage, Canberra.

'Take a little longer, take a different route.' Take the time to assess areas of your property that you do not regularly travel to and be thorough with your management techniques (Goulburn workshop).

'If you keep at it, you can beat it.' Land managers need to actively assess their tussock situation and not tolerate it (Canberra workshop).

Working together

Social issues

Serrated tussock can affect people and communities in rural, semi-rural and urban settings. Due to the diverse range of areas it occurs, and because it spreads easily across property boundaries, the issues facing communities with serrated tussock are complex and varied.

Such issues may include:

- Infestations seem overwhelming and control may not be conducted due to the perception it is too difficult.
- Not everyone is aware of their responsibilities relating to serrated tussock control.
- Continual seed rain from nearby uncontrolled infestations.
- Prior to purchasing new land, purchasers may not be aware of the serrated tussock history.
- Landowners may not fully understand the consequences of not managing serrated tussock or may not have the knowledge or equipment to properly control it.
- Some non-resident land holders may not appear to be managing their weed problems.
- Some landowners have difficulty in identifying serrated tussock from native tussock and grasses, leading to late management; or to inappropriate control of valuable native grasses.
- Where development is planned in urban areas, a perception exists that little control occurs.
- People too ill or elderly to effectively control serrated tussock may have heavily infested properties.
- Weeds are not always considered a main priority by some property owners and may lack motivation to spend money controlling them.

To address the problems associated with serrated tussock, a coordinated and community-based approach is required. Serrated tussock is everyone's problem and unless tackled together, it will be difficult to successfully manage into the future.

'Be honest with yourself.' If you aim to eradicate tussock on your property you need to have realistic goals and time frames to keep you on track (Geelong workshop).

'Learn to live with serrated tussock.' Set goals to keep you motivated and think on a long-term basis about what you would like to achieve. Be committed in the long-term to control tussock (Cooma workshop).

Develop clear short-term and long-term objectives for your situation. A strategy should be adaptable to all seasons and multiple situations (Attwood workshop).

A community based approach to managing serrated tussock

Community groups can take on many different forms and are not necessarily confined to established, government-funded bodies. They may be a social group of neighbours that give each other a helping hand, a group of people with similar interests or circumstances, a Landcare group or even a larger group made of individuals in surrounding areas. It doesn't matter what the group is called, as long as the people in the group share a common purpose.

All it may take for a community to start working together is one land holder recognising that their serrated tussock situation may be a bigger problem than they can handle on their own, and realising that they need to work with others in their local area to have success in controlling it.



DPI Victoria



DPI Victoria

Community rehabilitation project on serrated tussock infesting steep land.

Getting started

If wanting to start a serrated tussock group, or find out if something already exists in an area, there are many people that can assist. Some include:

- government agency staff, including Landcare coordinators and regional weed coordinators
- community group representatives, including catchment management or natural resource management authority representatives
- council weed officers
- land holders already in an active group.

Contact information for different organisations can be found on page 114.

To take the next step towards starting or being involved in a community group devoted to serrated tussock control and management, some suggestions on how to start are:

- ask neighbours what they are doing about serrated tussock
- attend local field days, workshops or farm walks
- have a barbeque and invite neighbours and a specialist to speak
- visit other community groups who are working on serrated tussock
- seek out someone who has had some success in their fight against serrated tussock and ask them for advice and ideas.

While there is a need for communities with serrated tussock to become actively involved in control, it is just as important for communities adjacent to serrated tussock infestations to work together to prevent invasion. Every community with serrated tussock should have a planned coordinated approach.

Case study 6 describes how a community has worked together to manage serrated tussock.

A community based approach to managing serrated tussock

The following are some ideas that groups engaged in serrated tussock have suggested—this information comes from a series of workshops held in south-east Australia and other sources.

- Work together as a team with an aim to eradicate serrated tussock over the long-term. Work together to reduce the likelihood of spread and invasion from adjoining land by undertaking preventative measures across a region. Provide support to all other group members.
- Encourage new people to the area to become members.
- Gather relevant information on serrated tussock such as identification, management, control, regulations, and planning.
- Undertake group training and education, such as:
 - identification of serrated tussock
 - calibration of equipment or a farm chemicals course
 - property planning
 - organise field days or demonstration sites.
- Be proactive in regular monitoring and follow up programs across your region.
- Organise coordinated serrated tussock control programs. For example, bulk purchase of herbicide or coordinated aerial spraying.
- Build relationships with public land managers who own adjoining lands. Let them know what standards are expected in their serrated tussock management and which areas of public land are of most concern to you or your group.
- Adopt a regional ‘mother lode’—a hard to manage area or seed source—and work together on this area.
- Find out if there is any funding or volunteer help available to your region for controlling serrated tussock. Ask your Landcare coordinator how to better manage public liability, occupational health and safety or insurance issues involved with volunteers working on your land—they effectively become employees.
- Consider how your group could be supported by external funding opportunities. It may be possible to receive some natural resource management or environmental funding by focusing projects on biodiversity conservation, sustainable use of natural resources, and community capacity building.

Field day focussed on serrated tussock in the Monaro region of NSW.



Don Clinton



DPI Victoria

Roadside signage can help raise the awareness of a weed issue.

'There is no shame in having it (serrated tussock); the shame is not doing anything about it' (Geelong workshop).

Mutually discuss and assist neighbours with serrated tussock (Hobart workshop).

Ownership of the tussock infestations is an issue. 'It's easy to blame someone else but it's a big cop out!!' (Cooma workshop).

Enjoy a beer with your neighbour to break the ice and talk to them about weed management (Hobart workshop).

Section 3

Developing a control program

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Control guide

No single technique should be relied on to manage serrated tussock. Each situation will require a different combination of control methods to achieve success.

Serrated tussock control and management will require a long-term strategy. There is no quick fix or one-off solution; however, following these simple guidelines may assist in providing long-term control.

Prevention

- Learn to correctly identify serrated tussock, particularly when not in flower.
- Prevent serrated tussock from entering your property.
- Control invasions early.
- Prevent serrated tussock plants from flowering and seeding.

Destroy adult plants

- Kill adult plants to reduce seeding and addition to the soil seed bank.
- Rotate herbicides with different modes of action to reduce the chance of resistance.

Out-compete seedlings

- Suppress the growth of seedlings by promoting and increasing the growth and competition of desirable species.
- Avoid overgrazing pastures.

Follow up

- Regularly monitor control efforts and high risk areas such as fence lines and vehicle tracks.
- Always follow up with suitable treatments for your situation.

Regardless of the situation or density of the infestation, control programs that only focus on treating the existing serrated tussock plants and do not invest in prevention strategies and pasture management may find themselves continually fighting reinvasions. More information on IWM is provided in Section 2.

When choosing control options, it is also important to consider the legal requirements in your local area for serrated tussock control. For example, if serrated tussock must be destroyed, then it would be inappropriate to only use options such as spray topping, slashing or burning as these methods do not kill the plant—though will provide temporary relief from annual seed-set. Regulatory details are given on page 112.

To assist in developing a control program, see table 2 on pages 42–43. This table can provide guidelines to help you decide which control and management methods to use, for different land-use situations and densities of serrated tussock. The information obtained from the table can then form the basis of an integrated control program to suit your specific situation.

Making a decision about what kind of control measure is required for your situation requires common sense. Your aim should be to reduce serrated tussock density and prevent serrated tussock from seeding on your property. This is likely to require a mixture of techniques depending on your situation. Think carefully and plan before undertaking any control action and ensure it is suitable for your situation and long-term plan. It could be short-term gain for long-term pain, if it is inappropriate.

How to use the control table

- 1. Situation or land-use:** select the land-use category from the top row that best suits your situation. Land-use has been separated into the categories: introduced pasture, degraded pasture, native pasture, conservation native grasslands, steep/rocky/woodland and urban. Definitions for each are provided on the following page.
- 2. Density:** select the density of serrated tussock. This will be either light (L), medium (M) or heavy (H). Use the density description and pictures shown on page 30–31, to help determine which density rating to use. The distribution and density of serrated tussock can vary throughout a paddock,
 - L** – light or low density. Few or many individual scattered serrated tussock plants that cover less than 10% of the area.
 - M** – medium density. Serrated tussock covers 10–30% of total ground cover.
 - H** – high density. Serrated tussock covers more than 30% of total ground cover.
- 3. Treatment:** follow the column under the chosen land-use and density to see which control methods are best suited for your situation.
- 4. Control considerations:** obtain further information on control and management from sections 3 and 4.

Land-use	Description
Introduced pasture	A productive, agricultural pasture that consists predominantly of palatable introduced perennial grass and legume species. The land is arable and used for grazing purposes. The desirable vegetation is in good condition ¹ .
Degraded pasture	Pasture consisting mostly of introduced palatable perennial grass and legume species. The pasture in poor condition ² , containing large areas of bare ground. The land is arable and used for grazing purposes, and the pasture will require renovation to be productive.
Native pasture	Grazed pastures used for agricultural production that consist mostly of a mix of native grasses and forbs. Species may include kangaroo grass, weeping grass, spear grass, wallaby grass or red grass. Pasture may or may not include introduced legume species, for example, subterranean clover. The desirable vegetation is generally in good condition ¹ or if over grazed, would have the capacity to regenerate. ***Native pastures can NOT be cultivated, sprayed or destroyed by any means, unless prior approval is given by your government authority. State and federal Acts prevent removal of native pasture ***
Conservation native grasslands	Native grasslands have high biodiversity values and are a remaining remnant of previous widely distributed ecosystems. They possess a diversity of grasses, forbs and other species, including rare and endangered flora and fauna that requires active management and protection. Conservation native grasslands are generally non-grazed and non-arable ³ .
Steep and/or rocky terrain	These areas are non-arable ³ and generally used for grazing or conservation purposes. These areas may not have high agricultural productivity and have slow vegetation growth. The desirable vegetation may be either native or introduced. Land may be difficult to access. Rocky areas may occur on land that is not steep.
Woodlands	Contains native tree or shrub species and may have native grasses and forbs in the understorey vegetation. Woodlands are non-arable ³ and may be used for conservation or grazing purposes. Usually this land-use has little agricultural production value. Land may be difficult to access.
Urban situations	Areas located within an urban context. For example, roadsides, neglected land, parks, reserves, rail or utility corridors, land for sub-division or development and industrial areas. The desirable vegetation may be predominantly native or introduced species.

¹ Good condition – a pasture used for agricultural production that has a high proportion of desirable pasture grass (introduced or native) and legume species, little bare ground and a low amount of weeds. If serrated tussock was removed from this pasture, the remaining desirable vegetation would be actively growing and provide enough ground cover to hinder the establishment of serrated tussock seedlings.

² Poor condition, or a degraded pasture – a pasture used for agricultural production that has a low proportion of desirable pasture species, and a large amount of bare ground and weeds. The existing ground cover and growth of the pasture would not provide enough competition to prevent serrated tussock seedlings from establishing. Pastures of this kind will require re-establishment to be competitive.

³ Non-arable land is not suitable for cultivation. This may be because the land is steep, rocky or covered in trees, contains native pasture, rare or valuable species, or has shallow, fragile or sodic soils.

A property, management area or paddock may have different land uses and soil types within it, as well as different densities and distributions of serrated tussock. Therefore it is necessary to incorporate a variety of management techniques for control to be successful.

Different land uses require different management to effectively maximise perennial grass content, competition and production.

Situation/ Land-use Control Method	Agriculture					
	Introduced (perennial)		Degraded pastures (introduced)		Native pasture	
Density levels	L	M-H	L	M-H	L-M	H
Non-chemical						
Manual removal/chipping	✓	?	✓	?	✓	✓
Cultivation	×	?	✓	✓	×	×
Mulching	×	×	×	×	?	?
Fire	×	×	×	✓	×	×
Chemical control						
Spot spray – glyphosate	✓	?	✓	?	✓	✓
Spot spray – flupropanate**	✓	?	✓	?	✓	✓
Broadacre^ spray - glyphosate	×	?	✓	✓	×	?
Broadacre^ spray – high label rates flupropanate**	×	✓	?	✓	×	×
Broadacre^ spray seedlings- low label rates flupropanate**	?	✓	?	✓	×	?
Spray top	?	?	✓	✓	×	?
Wick wipe	✓	✓	?	?	?	✓
Competition						
Cropping	×	?	✓	✓	×	×
Pasture renovation	✓	✓	✓	✓	?	?
Grazing management	✓	✓	✓	✓	✓	✓
Forestry/native re-vegetation	×	×	×	×	×	?
Prevention of spread						
Fencing	?	✓	?	✓	?	✓
Shelter belts / windbreaks	✓	✓	✓	✓	✓	✓
Slashing	?	?	?	?	?	?
Stock management	✓	✓	✓	✓	✓	✓
Vehicle / machinery hygiene	✓	✓	✓	✓	✓	✓
Case study	1, 2, 3, 10	1, 2, 3, 10	1, 2, 3, 10	2, 3, 10	1, 4, 9	4, 9

Table 2: Serrated tussock control table

- ✓ = recommended control method
- ? = control method may be useful but can have variable results, require caution or may be logistically difficult to implement
- ×
- * Non-arable land that is not suitable for cultivation.
- ** Flupropanate can be very damaging to many native grass species.
- ^ Broadacre treatments include ground boom spray and aerial spray applications.

Agriculture/Environmental – non-arable*						Urban areas (roads, rail, parks, reserves)		Case study
Conservation Native Grasslands		Steep / Rocky		Woodlands		L	M-H	
L-M	H	L	M-H	L	M-H			
✓	✓	✓	?	✓	✓	✓	✓	1,2,3,8
×	×	×	×	×	×	×	✓	3,10
✓	?	?	×	?	×	✓	?	3
?	✓	×	?	×	×	×	✓	2
✓	✓	✓	?	✓	?	✓	✓	1,2,3,4,7,9
✓	✓	✓	?	✓	?	✓	?	2,4,7,9,10
×	?	×	?	×	×	×	✓	2
×	×	×	?	×	?	×	✓	1,2,4
×	×	×	?	×	?	×	✓	4,6
×	?	×	?	×	?	×	✓	
?	✓	×	×	×	×	✓	✓	
×	×	×	×	×	×	×	×	1,2,3
×	×	×	?	×	?	×	✓	1,2,4,6,10
✓	✓	✓	?	✓	?	×	×	1,2,3,9,10
?	?	✓	✓	✓	✓	×	×	1,4
?	✓	?	✓	?	✓	?	✓	1
✓	✓	✓	✓	✓	✓	?	✓	1,2,3,4,6
?	?	×	×	?	?	✓	✓	
?	?	✓	✓	?	✓	?	?	
✓	✓	✓	✓	✓	✓	✓	✓	5,8
7	7	4	4	4, 9	4, 9	5, 6, 8	5, 6	

Density levels

- L** Light or low density where there are few or many individual scattered plants. Less than 10% of the area is covered in serrated tussock.
- L-M** Density that is light to medium with less than 30% of area covered in serrated tussock.
- M-H** Density that is medium to high with greater than 10% of the area covered in serrated tussock.
- H** High density of serrated tussock that covers greater than 30% of an area.

All situations – occasional plants only



Charles Grech

Best practice

- Learn to correctly identify serrated tussock as both an adult plant and seedling.
- Chip out (manually remove with mattock or hoe) individual plants or spot treat individual plants with glyphosate or flupropanate using a carefully directed spray. In bare ground created by spot treatments, scatter pasture seed and fertiliser to promote ground cover and competition with serrated tussock seedlings.
- Treat plants to prevent flowering.
- Maintain ground cover of desirable vegetation at 90–100%.
- Regularly monitor treated areas for the emergence of seedlings.
- Follow up with either spot spraying of glyphosate or flupropanate, or chip.

Impact of control

- Serrated tussock plants killed.
- Little to no impact on the desirable vegetation/pasture or production levels, provided spot treatment has been used correctly, see page 67 for more information.
- Establishment of serrated tussock seedlings is reduced.

Considerations

- Do not underestimate density—look carefully for both seedlings and adult plants.

Cautions

- Over spray of glyphosate or flupropanate may damage desirable vegetation.
- If using flupropanate, some desirable vegetation may be affected by the residual chemical in the soil.
- If serrated tussock seed heads are present on chipped plants, bag them to prevent seed drop, remove from the paddock and burn.

'See a tussock, kill a tussock.'
Control serrated tussock when you first see it and be proactive in your management
(Bathurst workshop).

'Identify as soon as possible.'
Implement control as soon as it is located for the first time
(Hobart workshop).

Agriculture

Introduced pastures



Aaron Simmons

Light infestation.



Malcolm Campbell

Medium infestation.



Charles Grech

Medium infestation.



Charles Grech

High infestation.

Best practice

All infestation levels

- Spot spray individual plants with glyphosate or flupropanate with a carefully directed spray. Spot treatments can still be very effective in medium to high infestations, but will require considerable time and resources. Alternatively, wick wipe—may require several applications (see page 69–70 for more information).
- Implement best practices for pastures to increase cover of desirable species to 90–100%.
- Rotationally graze pasture to allow periods of rest for pasture to regenerate and maintain competitiveness. Avoid overgrazing—aim to keep the pasture at 1200–1500 kg DM/ha during summer or times of moisture shortage (about 4–5 cm high).

- Regularly monitor and follow up control by spot spraying or chipping.
- Practice property hygiene and use preventative measures such as shelterbelts and/or mesh fencing to reduce seed spread for the long-term.

Light infestation

- Chip out individual plants, then scatter pasture seed and fertiliser in bare ground left by chipping or spot spraying, to promote ground cover and competition with serrated tussock seedlings.

Medium to heavy infestation

- Broadacre spray (ground or aerial application) with label rates of flupropanate to kill existing serrated tussock plants. Use lower label rates on lighter soils. Some non-target damage may occur.

- Increase pasture competition using local best practices such as, broadcast or direct drill pasture and legume seeds, and top dress with fertiliser and lime/gypsum.

Impact of control

- Spot treatments have little impact on surrounding desirable vegetation provided the herbicide is applied accurately.
- Pasture productivity is likely to increase when infestation levels are reduced and desirable pasture species are increased.
- Stock withholding periods apply if flupropanate is used.
- Long-term—a reduced population of adult serrated tussock plants will lead to a decrease in seed production and a reduced soil seed bank.

Other options for control

- Light infestations – broadcast applications with low label rates of flupropanate may be an option to treat serrated tussock seedlings.
- Only consider spray topping or slashing if seeding is imminent and no other alternatives are available to either stop or delay flowering.

Considerations

- Avoid using treatments that cause significant non-target damage to desirable vegetation.
- Make steady progress towards restoring pasture to high levels of productivity and low levels of serrated tussock.
- If density is at very high proportions (close to 100% cover of entire paddock), consider cropping rotations and pasture re-establishment (see pages 71–72 for more information).
- If the level of serrated tussock you are treating becomes so high that you are effectively blanket spraying a large area

with a hand held spray unit, then consider options appropriate for medium to high level infestations.

- For wick wiping, ensure there is a distinctive height difference between serrated tussock and the desirable vegetation.
- Have strategies in place to reduce the impact of pest animals. Pest and native animals can add to the serrated tussock problem by grazing desirable plants to ground level, leaving bare areas vulnerable to invasion. Controlling pest animals may help reduce the grazing pressure on the pasture and increase ground cover.
- Consider mesh fencing to rabbit proof quality to:
 - capture some of the tumbling serrated tussock seed heads and thereby reduce spread
 - help control rabbit and other feral animal populations
 - subdivide paddocks into different land-uses so they can be managed to suit an individual situation.
- Follow up control with further spot treatments.

Cautions

- If seed heads are present on chipped plants, consider bagging the plants, remove from paddock and burn.
- Glyphosate will kill all green actively growing vegetation.
- Some non-target damage may occur to pastures treated with flupropanate. Lower label rates may be more selective; higher label rates can be very damaging for long periods of time. Soil types can also influence the effectiveness and residual life of flupropanate.
- Non-target damage may occur with wick wiping.

A technique highly regarded by farmers is chipping with a mattock and adding pasture seed and fertiliser to the bare area. This technique aims to provide new ground cover and reduce the re-emergence of tussock seedlings through strong competition. One land holder uses a salt shaker of seed, applying a rate of 10 shakes per tussock plant (Goulburn workshop).

‘If you miss a tussock it will flower and seed.’ Attack serrated tussock when the infestation is small and controllable. Avoid leaving management until the last minute (Canberra workshop).

Focus management to continually improve the quality of pasture to promote the growth of desirable species and reduce the rapid emergence of tussock (Goulburn workshop).

Degraded introduced pastures



Natasha Baldyga



Charles Grech

Best practice

All infestation levels

- Start a pasture renovation program as soon as possible.
- Kill all existing vegetation with a broadacre application of glyphosate.
- Cultivate/plough to prepare ground for sowing crop or pasture.
- Crop land for at least two years before sowing back to pasture.
- Seek advice to determine the best crop or pasture mix and fertiliser regime for each paddock. Try and choose a good growing year with adequate rainfall to enable pasture or crop establishment.
- Avoid grazing re-sown pastures during establishment phase. Then rotationally graze to maintain pasture vigour (see page 74 for more information).
- Practice machinery and vehicle hygiene procedures to prevent seed spread between paddocks.
- Maintain a diligent follow up program of spot spraying with glyphosate, using a carefully directed spray, particularly while pasture is establishing.

Impact of control

- Broadacre herbicide application will kill existing serrated tussock plants, and all other vegetation. It is critical to follow up with a cropping program.
- Costs of cropping, pasture re-establishment and maintaining soil fertility can be high.
- Cropping may provide feed for stock during times of feed shortages.
- Timing is critical, particularly during times of drought and low water availability.

- Long-term value of serrated tussock control is high as:
 - pasture productivity is increased
 - seed bank levels of serrated tussock are reduced.

Other control options

- For light infestations, a short-term option may be to chip or spot spray serrated tussock plants with glyphosate or flupropanate until ready to undertake a full pasture renovation.
- An alternative to broadacre application of herbicide is to wick wipe prior to cultivation.
- Fire may be an option to clean up paddocks prior to cultivation if the serrated tussock infestation is large.

Considerations

- Special attention must be given to seasonal conditions as pastures and crops will not grow or establish without adequate rainfall.
- Forage or commercial crops are an option.
- If the vegetation consists mainly of native species, refer to information on how to treat serrated tussock in a native pasture situation.

Cautions

- Residual flupropanate may affect the growth of crop or pasture species. Leaching rain of at least 100 mm must fall before sowing a crop or pasture after using flupropanate (see pages 63–65 for more information).
- Withholding periods apply if flupropanate is used.

'A vigorous weed needs a vigorous response' (Goulburn workshop).

Native pastures



Aaron Simmons

Light infestation.



Aaron Simmons

High infestation.

Best practice

All infestation levels

- Learn to correctly identify serrated tussock from valuable native species.
- Kill existing serrated tussock plants by chipping or spot spraying with glyphosate or flupropanate, using a carefully directed application. Priority should be given to adult, seed producing plants. Scatter pasture seed and fertiliser into bare ground left by spot treatments. This may be labour intensive in high level infestations; however, the impacts of larger broadacre treatments are too severe and may greatly reduce the presence of native species.
- An alternative to spot treatments is to wick wipe.
- Rotationally graze to rest pasture from grazing and allow native grasses to set seed. Keep the level of desirable grasses high, particularly over the summer period. See page 74 for more information.
- Maintain a vigorous pasture with 90–100% ground cover.
- Regularly monitor and follow up serrated tussock managed areas for regrowth. Chip or spot spray with herbicide as required.
- Plant tree shelterbelts or erect mesh fencing to reduce seed spread in the long-term.

Light to medium infestations

- Mulch may be used along fence lines, between and around rocks or environmental areas that require rehabilitation, such as creek banks.

Impact of control

- Spot treatments will have little impact on desirable vegetation as long as the herbicide is applied correctly, as a carefully directed spray. Remaining native species may continue to grow and provide a competitive ground cover.

Other control methods

- Apply fertiliser only to modified native pastures that contain legumes.
- Use slashing as a last resort to delay seed-set if unable to prevent flowering by other control methods.

Heavy infestations

- Broadacre application of low label rates of flupropanate in areas that are difficult to access—use with caution (see pages 63–65 for more information).
- Broadacre application of glyphosate when native grasses are completely dormant—use with caution as may reduce production (see page 62 for more information).
- Where large areas of bare ground exist, increase pasture biomass by direct drilling or aerial broadcast seeding of clover and/or native grass seed in native pastures that have already been modified. Results may vary. Seek the advice of a local agronomist.
- Consider retiring the land from agriculture and returning it to native bushland or scrub in situations where the native pasture is beyond repair and native species would be unable to regenerate to successfully compete with serrated tussock.

- Only spray top to prevent seeding if unable to kill plants prior to seeding. This method is short-term and must be followed up with a control method that will kill serrated tussock plants.

Considerations

- Know the species within the pasture as this will determine the best control methods to use. Native grass species are categorised as either C₄ (summer growing grasses) or C₃ (winter or yearlong green growing grasses). More information on C₃ and C₄ grasses is on page 66.
- Avoid treatments that may cause damage to desirable vegetation.
- Do not overgraze pastures, particularly over summer. This can make them vulnerable to invasion, as serrated tussock typically germinates in the autumn.
- Reduce stock numbers until the infestation is reduced, then reassess grazing management strategies.
- When wick wiping, ensure there is a distinctive height difference between serrated tussock and the desirable vegetation.
- For mulching to be effective in small areas, desirable species must be planted into the mulch to provide ground cover and competition. For more information see page 59.

Cautions

- Residual properties of flupropanate may prevent the growth of some native species.
- Overgrazing will lead to bare ground and increased chances of serrated tussock invasion.
- Broadacre application (aerial or ground) of flupropanate may kill many beneficial plant species required to provide competition for serrated tussock seedlings.
- Do not use flupropanate in a broadacre application if the desirable native vegetation consists predominantly of C₃ native grasses. These grasses are very susceptible to this herbicide and its use may result in the removal of most vegetation for a number of years and the invasion of other weeds. Once the residual affect wears off, the area may quickly become dominated by serrated tussock again if there is no existing vegetation left for ground cover and competition.
- If using glyphosate in a broadacre application, it is essential to know the lifecycle of the plant species present in the pasture. Glyphosate will kill most plants that are actively growing at the time of application. For example, do not treat a pasture that contains mostly C₄ grasses with glyphosate during summer, as this is their main period of growth. For more information see pages 62–63 and 66.

*****A thorough knowledge and understanding of the herbicide you are using, your pasture species and their lifecycle is required to effectively use herbicides in a broadacre application*****

Agriculture/Environmental – non-arable

Conservation native grasslands



Best practice

All infestation levels

- Chip or spot spray serrated tussock plants with herbicide, using a carefully directed spray. This may be labour intensive for medium to high level infestations; however, the impacts of larger broadacre treatments are too severe.
- Allow natives species to set seed.
- Maintain a high level of ground cover and vegetation.
- Maintain a healthy stand of native species with periodic reductions of native grass/forb biomass. This may be achieved by either burning, grazing or strategic (high blade settings) slashing. Seek expert advice before undertaking.
- Always monitor and follow up control efforts with spot spraying or chipping.
- Plant appropriate species of trees and shrubs to act as windbreaks/shelterbelts or erect mesh fencing to reduce the impact of seed blowing in from nearby infestations.

Impact of control

- Continued spot treatment of serrated tussock will have long-term success provided there is little damage caused to the desirable native species from control treatments.
- Fire is an important part of the grassland lifecycle; however, it also stimulates a mass germination of serrated tussock. Always have a diligent follow up control program of spot spraying if using fire.

Other control methods

- Mulch small areas of serrated tussock and re-vegetate with suitable native species. Wick wipe with herbicide only if able to get a distinctive height difference between native species and tussock. This may be difficult to achieve in conservation areas where grazing is not used.
- Native grasslands with large areas of bare ground and high levels of serrated tussock may benefit from a re-vegetation program. In this situation, allowing the natural regrowth of native species is preferred as it involves little to no soil disturbance. Broadcast seeding of native species suitable to the area may also be used; however, results can be variable.
- For heavy infestations, broadacre application of glyphosate may be used when native grasses are completely dormant—use with extreme caution (see page 62 for more information).
- Slash or spray top only as a short-term solution to delay flowering of serrated tussock.
- Practice vehicle hygiene procedures to reduce seed spread.

Considerations

- Kangaroos and pest animals can place significant grazing pressure on native species.
- In areas where bare ground exists, restoration of native species and biodiversity levels is important.

Cautions

- ‘Locking-up’ native grasslands away from natural disturbances, such as fire, can have a detrimental effect on the grassland community. Grasslands are adapted to irregular fire events and actually require periodic biomass removal to regenerate native species and stimulate the germination of native plants. Timing of events is critical.
- Always use fire with caution, even in areas of native vegetation as results may be unpredictable. Always monitor regrowth and be prepared for spot treatments of regrowth.

Steep, rocky or woodland areas



Michael Michelmore

Light infestation.



Luke Pope

Medium infestation.



Chelsea Wardrope

Light infestation.



Byron Stein



Malcolm Campbell

Heavy infestation.

Best practice

- Chip or spot spray light infestations, if possible, using a carefully directed spray, with flupropanate or glyphosate. Make use of all terrain vehicles for spot treatments.
 - o Scatter pasture seed and fertiliser in bare ground left by chipping or spot spraying, to promote ground cover and competition with serrated tussock seedlings.
- Reduce stocking rates and the frequency of grazing. Rotationally graze and include long periods of rest to allow the desirable vegetation time to regrow and for native species to set seed. Do not overgraze. See page 74 for further information.
- If the serrated tussock infestation in this situation comprises a 'mother lode', employ strategies to reduce seed spread into productive areas.
- Follow up treatments by spot spraying regrowth.
- Avoid using broadacre treatments for light or scattered infestations as they could be detrimental to beneficial species.

Medium to high density levels on land that is steep, inaccessible and/or covered in trees:

- strongly consider retiring the land from agricultural production and allow it to regenerate back to native scrub or assist in this process by planting native species (see pages 77 for more information)
- broadacre application (aerial) of flupropanate to selectively remove serrated tussock. This method requires caution as damage to desirable vegetation may occur. See page 63 for more information.
- plant a shelterbelt of trees, particularly along ridges to reduce seed spread in the long-term.

'You aren't reducing the level of productivity because you are tackling unproductive land anyway.' Fence off an infested area and make it a 'biodiversity block' (Bacchus Marsh workshop).

Impact of control

- Broad-scale spraying requires follow up vegetation management.
- Diligent spot control, in association with grazing management may increase desirable grass species, resulting in increased pasture production.
- May be a short-term trade off in lost production for the long-term control of serrated tussock.
- Implimentation of prevention strategies may result in reduced spread and reinvasion of serrated tussock.

Other control methods

Medium to high infestations

- On open flat rocky areas that contain introduced pasture species as the desirable vegetation: undertake pasture renovation by using specialised all terrain seeding equipment to direct drill pasture seed into rocky terrain (see page 72 for more information).
- If the desirable vegetation is predominantly introduced species, use broadacre treatment with low label rates of flupropanate to remove seedlings.
- Depending on the dominant vegetation, alternatively use glyphosate when desirable species are completely dormant—timing is critical, see page 62 for more information.
- After herbicide treatment, aerial broadcast of pasture seed and fertiliser may help increase the level of desirable species; however, results can be variable. Pasture will need to be locked up for at least one year so plants are able to establish and set seed prior to being grazed.
- Farm forestry may be an option in some areas. Information on forestry options are best obtained from a farm forestry advisor.

Considerations

- If a change in land-use is needed to effectively control serrated tussock, a long-term plan will be required. For further information on planning, refer to section two.
- Consider undertaking a control strategy with neighbours if the adjoining steep or rocky land is owned by another party.

- Use a suitable vehicle—four wheel drive, all terrain vehicle, or motorbike—horse or on foot, to access areas safely. Some remote controlled powered spray reels can greatly assist spot spraying.
- For light infestations, mulching may be an option in rocky outcrop areas. See page 59 for more information.
- Control pest animals that graze out desirable grasses and vegetation. Rabbit mesh fencing can play a dual role in these situations; to reduce the spread of seed heads and to help keep rabbits out of the area. Rabbit control will also need to be undertaken within the paddock for this to be successful.
- Consider using mesh fencing for the following reasons:
 - restrict stock access to the area and only allow low levels of grazing
 - assist in the control of pest animals
 - may act as a small barrier to capture the tumbling serrated tussock seed heads— not applicable for very steep areas.

Cautions

- Be aware of how herbicides can affect the desirable vegetation. For more information see pages 61–63.
- Do not aerial spray flupropanate if there are large amounts of C_3 native species in the desirable vegetation.

Urban areas



Natasha Baldyga

Rural roadside.



Kate Cunnew

Urban house fence.

Best practice

All infestation levels

- Learn to correctly identify serrated tussock.
- Kill serrated tussock plants by chipping or spot spraying with glyphosate or flupropanate, using a carefully directed spray, or alternatively wick wipe. Where soil disturbance has occurred, broadcast pasture seed and fertiliser to increase desirable vegetation levels.
- Slash or mow only as a short-term solution to delay the flowering of serrated tussock.
- Use methods that will reduce seed spread, such as fencing off reserves, private land and roadsides and practice machinery and vehicle hygiene procedures.
- Regularly monitor infestation levels and carry out follow up control activities.

Impact of control

- Targeted spot treatments will have little effect on the desirable vegetation.
- Preventing flowering will eventually reduce serrated tussock seed bank levels.

Other control methods

- In some situations where native species are present and limited options are available for control, for example, large reserves or rail corridors, fire may be used to remove existing vegetation and help native grasses re-establish and compete. A mass of serrated tussock will return following a fire, therefore a strict follow up regime will be necessary.

- Broadacre treatments of glyphosate or flupropanate can be made in medium to high level infestations of serrated tussock provided herbicide precautions are considered and follow up of seedlings is undertaken.
- In high density infestations, only use spray topping as a short-term solution to delay flowering.
- Use mulch after adult plants have been removed in small areas that are heavily infested with serrated tussock, especially in conservation areas that require rehabilitation.

Considerations

- Serrated tussock control in urban areas is a multi stakeholder responsibility and all stakeholders need to know of their responsibilities.
- Use good hygiene practices, especially on machinery and equipment used for roadside slashing purposes. The potential for serrated tussock, and other noxious weeds, to spread in these situations is enormous.
- For wick wiping, ensure there is a distinctive height difference between serrated tussock and the desirable vegetation.

Cautions

- Fire is very risky and should always be conducted with the appropriate permits and in conjunction with the local fire authority.

Nationally protected ecological communities

Land managers need to be aware that infestations of serrated tussock may occur in or near to matters protected under the Australian Government *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Nationally threatened species and ecological communities are the protected matters most likely to be encountered during treatment of weed infestations. It is important that weed management practices take into account the possibility that control activities may have adverse impacts on matters protected by the EPBC Act.

Threatened ecological communities

Serrated tussock may occur in three listed ecological communities (as at September 2008). However, ecological communities continue to be added to the list so land managers need to take note of what new listings, if any, have occurred in their region.

The listed ecological communities that are currently most relevant to serrated tussock infestations are:

- Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory (endangered); Natural Temperate Grassland of the Victorian Volcanic Plain (critically endangered); and
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (critically endangered).

The Department of the Environment, Water, Heritage and the Arts provides detailed information about each listed ecological community on its website at: www.environment.gov.au/cgi-bin/sprat/public/publiclookupcommunities.pl. The information available includes a listing advice, maps and information guides. The information guides, in particular, are aimed at helping landowners identify and manage listed ecological communities and understand the implications of the listing.

Since 2006, the ecological community descriptions in the listing advice are detailed and include clear condition thresholds to identify remnant patches that are in good condition. Patches that do not meet the condition thresholds are not part of the listed ecological community and do not trigger the EPBC Act. However, they remain eligible for funding to improve their condition.

National listing recognises that an ecological community's long term survival is under threat. The intention of listing is to prevent any further decline and to promote and assist recovery with the co-operation of landholder and community groups. Under the EPBC Act, any new or intensified activity likely to have a significant impact on a listed ecological community should be referred to the Minister for the Environment, Heritage and the Arts for assessment and approval of the likely environmental impacts.

Note that some exemptions to referral and approval under the EPBC Act may apply. These exemptions may allow land managers to continue to use their land in the same way as before, providing that they do not significantly change or intensify their activities and the activity was lawful.

A key message to landholders is that, if they retain a high quality patch of a listed ecological community on their property then they should be congratulated for applying good management, and they should be encouraged to continue their existing management practices. There are benefits to the long-term protection of native biodiversity. Native vegetation remnants provide a range of ecosystem services across an area of Australia regularly hit hard by drought, including management of water and soil nutrients, reducing erosion and salinity, and carbon storage. Another key service is the resilience of undisturbed, good quality native vegetation remnants to climate change and the spread of invasive weeds, such as serrated tussock.

Ramsar wetlands and other protected matters
The environment reporting tool at www.environment.gov.au/erin/ert/index.html will provide land managers with a list of all the protected matters likely to occur in an area where weed control is proposed. Guidelines to help determine whether the weed management activities will have a significant impact are available at www.environment.gov.au/epbc/guidelines-policies.html#guideline.

For further information about the EPBC Act visit <http://www.environment.gov.au/epbc/index.html>

For information about the referral, assessment and approval process under the EPBC Act visit www.environment.gov.au/epbc/approval.html

For information about exemptions under the EPBC Act visit www.environment.gov.au/epbc/about/exemptions.html

Farmers also are encouraged to use the services of the Environmental Liaison Officer at the National Farmers' Federation. The officer can be contacted by phone 1800 704 520 or email environment@nff.org.au.

Non-chemical control

Manual removal/chipping



Natasha Baldyda



Peter Fullerton

Chipping, also referred to as hoeing, is the physical removal of the entire serrated tussock plant from the ground using a hoe or mattock. In the bare ground left by chipping, scatter pasture seed and fertiliser to increase ground cover and promote competition.

Once removed from the ground, shake soil from the roots or leave in a position with the roots exposed to dry out. Otherwise the plant may re-root and grow. If chipped while in flower, bag the whole plant, remove from the paddock and burn.

Ease of chipping will depend upon soil type. Serrated tussock is more easily removed from soft/sandy soils compared to heavy/clay soils.

Suitable for:

- All land-use situations with scattered or light infestation levels.
- Follow up treatments to remove regrowth.

Timing

- All year, preferably before flowering. Ensure to treat any regrowth that follows.

Advantages

- Completely removes and kills plant.
- Low soil disturbance.
- Control without using chemicals.
- Can be carried out while doing daily property activities such as checking fences or water. Always carry a mattock (and seed for revegetation) on the bike or in the vehicle.

Disadvantages

- Uprooted plants may survive if moist soil is left around their roots.
- Labour intensive.

*'Can't beat a mattock'
(Canberra workshop).*

'Hoe, hoe, hoe!' (Bathurst workshop)

*'It's a matter of having a mattock on
the back of the ute'
(Attwood workshop).*

*Chipping will cause some degree
of soil disturbance, creating bare
patches. Ensure you replace these
patches with desirable species
(Hobart workshop).*

Mulching

Mulching is the physical application of material, such as straw, wood chippings, plastic sheeting or carpet, over the ground to prevent weed growth. This method will stop all smothered vegetation from growing, including all beneficial vegetation. To be effective, re-vegetate desirable species into the mulch layer.

For best results:

- chip serrated tussock plants or spot spray with glyphosate
- apply a mulch layer at least 10 cm thick to smother all existing vegetation
- plant seedlings or tube stock of desirable species into the mulch or weed mat to provide competition with emerging weeds. Use a crow bar to create a hole for tube stock to be planted through the weed mat or mulch
- regularly monitor for emerging serrated tussock plants, and other weeds
- follow up any regrowth by spot spraying with glyphosate or manually remove
- maintain the depth of mulch levels, as over time they will settle and decompose (Snell *et al* 2007).

Suitable for:

- Light or isolated infestations in urban areas. For example, parks, reserves, roadsides and backyards.
- Organic farming situations.
- Small area, high density infestations in environmental areas where vegetation rehabilitation is required. For example, creek banks or conservation native grasslands.
- Light infestations in difficult to manage terrain. For example, rocky, steep or treed country, or along fence lines.

Fire

A hot serrated tussock fire will not kill adult plants, though it will remove biomass and destroy about 25% of the serrated tussock seed bank. Mostly surface seed is destroyed as buried seed is unaffected by fire. Only use fire in combination with other control methods.

Burnt serrated tussock plants may regrow and fire stimulates the mass germination of serrated tussock seeds. Therefore, always carry out a vigorous follow up control program to remove serrated tussock seedlings, using an appropriate herbicide control technique suited to preserving the desirable background pasture species.



Len Menzel

Applying mulch to treat small infestations in a rocky outcrop may be useful.

Timing

All year

Advantages

- Does not require chemical application.
- Does not disturb the soil.

Disadvantages

- Not suitable for large scale infestations.
- Non-selective.
- Can be expensive.
- Labour intensive.

In an organic farm situation, mulch may be used to smother serrated tussock plants before flowering and does not disturb soil (Canberra workshop).



Charles Grech

Only use fire with appropriate permits and local fire authority.

Always follow up fire with a vigilant control program using techniques such as spot spraying.

Do not use glyphosate following fire until enough green leaf material is available for chemical uptake. Avoid using fire for at least 1 to 2 years following the application of flupropanate as it removes the herbicide residual from the soil.

Serrated tussock will produce a hot fire year round, which may have harmful effects on desirable vegetation. Always use fire with caution and seek advice when required.

Suitable for:

- Conservation native grasslands, where ecological biomass reductions are periodically required to maintain the health and rejuvenation of native species. Selective grazing by native and feral animals may increase serrated tussock populations in such situations, so burning may be one of few management options available.
- Degraded pasture situations where the removal of dry matter prior to ploughing is required.
- Urban areas such as large parks and reserves, only in collaboration with the local fire authority.

Timing

Best in late autumn to late winter—this may reduce seed-set and the summer fire hazard. If using fire, only burn once every two to three years.

In native pastures, winter burns are more effective in reducing the regrowth of serrated tussock and is best conducted when at least 1000 kg DM/ha (pasture about 3 cm high) of desirable competing vegetation is available (Badgery 2003).

Advantages

- Rejuvenates native grasslands to maintain diversity and healthy growth.
- May reduce the serrated tussock seed bank.
- May postpone serrated tussock from seeding for the current season.

Disadvantages

- Serrated tussock can regrow vigorously following fire and may produce more seed in the following flowering season.
- The seed bank of desirable native species may be too low to successfully compete with serrated tussock following a fire.
- Adult serrated tussock populations are a fire risk and should only be burnt with extreme care and caution—a hot burn conducted at the wrong time may generate a wind storm of seed heads, creating a dangerous fire risk.
- May leave large bare patches of ground.

<p>New South Wales Rural Fire Service 02 8741 5555 www.bushfire.nsw.gov.au</p>	<p>ACT Private land - Rural Fire Service 02 6207 8609 www.rfs.act.gov.au Public land - Parks, Conservation & Lands 02 6207 2488</p>	<p>Victoria Country Fire Authority 03 9262 8444 www.cfa.vic.gov.au</p>
<p>Tasmania Tasmanian Fire Service 03 6230 8600 www.fire.tas.gov.au</p>	<p>South Australia Country Fire Service 08 8463 4200 www.cfs.org.au</p>	<p>Queensland Rural Fire Service 07 3247 8130 www.ruralfire.qld.gov.au</p>

Always contact the local fire authority, check current fire restrictions and if required, obtain permits.

Chemical control

Herbicides are extremely beneficial in a serrated tussock integrated weed management plan; however, they should not be relied on as the sole method of control. Inappropriate use or heavy reliance of chemicals may lead to increase the chances of resistance occurring (see page 24 for more information).

Herbicide use requires correct timing and application rates to be effective, and will vary depending on the situation and density of serrated tussock.

When using herbicides, recording specific information may be required—each state has their own requirements for record keeping.

For all current label and minor-use permit details for serrated tussock control, visit the Australian Pesticides and Veterinary Medicines Authority at www.apvma.gov.au

Always carefully read and follow all label directions, material safety data sheets, and any off-label minor use permits.

Always follow up chemical control with other control measures.

Using only chemicals to control serrated tussock is NOT the answer.

Chemical selection

A number of herbicides are registered for controlling serrated tussock in Australian pastures. These include glyphosate, flupropanate and 2,2-DPA. Two main herbicides are currently used—glyphosate and flupropanate.

The use of 2,2-DPA relied heavily on burning of pastures after treatment. In areas where burning could not be implemented, such as improved pastures, or steep fire-prone areas, very high rates of the herbicide is necessary. The herbicide and the burning leave pastures very weak, unproductive, and vulnerable to invasion of weeds. As such, this herbicide is not generally recommended in this management guide. There may be instances where 2,2-DPA may be useful for treating serrated tussock and other weeds. The density and location of serrated tussock will determine the herbicide and application method to use.

Find up-to-date chemical registration details and current permits on the Australian Pesticides and Veterinary Medicines Authority (APVMA) website: www.apvma.gov.au

Table 3: Herbicides currently registered for use on serrated tussock in pasture situations (September 2008).

Active ingredient	State or Territory	Application method	Comments
Flupropanate	NSW, ACT, Vic, Tas, Qld, SA, WA	Ground & aerial application, spot spraying, spray topping and wick wiping. Refer to label for details on timing and rates.	See text. Can be combined with glyphosate products as instructed on the label. Withholding periods apply.
Glyphosate	Vic, NSW, Tas, ACT	Ground application, spot spraying and spray topping. Aerial application. Refer to label for details on timing and rates.	See text. Can be combined with flupropanate. No withholding period.
2,2-DPA	Vic, NSW, Qld, SA, WA	Broadacre and spot spray. Refer to label for details on timing and rates.	May take 6–8 weeks for full effect to be seen. May make pasture unproductive for a long period.

Glyphosate

A non-selective herbicide that kills green, actively growing plants. Careful application is essential to minimise non-target damage.

Characteristics of glyphosate include:

- absorbed through the leaves and green stems
- fast acting—kills treated plants one to four weeks after application
- not residual—ceases to work once it contacts the soil
- no withholding period for grazing stock; however, avoid grazing stock for seven days following application to allow absorption into the plant.



Regrowth of serrated tussock following mis-spray – will require follow up treatment.

Suitable for:

- All land-use situations. Application method will vary depending on the situation and density of the infestation.
- Spot spraying with glyphosate is suitable for all land-use situations; all pasture types and as an effective follow up treatment.
- If glyphosate is used prior to cropping or sowing new pasture, the land can be cultivated soon after spraying.

Application

- Apply by spot spray or broadacre—ground/boom or aerial spray.
- When spot spraying, always apply with a carefully directed spray, directly onto the plant to avoid over-spray.
- Complete coverage of the plant is necessary to kill serrated tussock. Any part missed, can survive independently. Take care to avoid over-spray to reduce damage to non-target species.

- Selectivity of glyphosate may be achieved by utilising the lifecycle of the desired pasture species, only if applied while desirable plants are completely dormant.
- Adding a surfactant or wetting agent may improve glyphosate penetration. A dye marker could also be added for spot spray applications to avoid spray misses or double applications.
- Always ensure equipment is properly calibrated, and the directions on the label are followed.
- Spray top with low label rates of herbicide only as a short term option to prevent seed-set in the current season.

Cautions

- If spraying around waterways, use a glyphosate formulation that is registered for use in this situation.
- Timing is critical when broadacre applications are used in pasture situations. Protection of desirable species is essential and land holders must be knowledgeable on the lifecycle of pasture species if considering using this as an option. Always seek specialist agronomist advice if in doubt. Be aware that some pasture damage may still occur.

Timing

Spot spray – apply any time of the year when serrated tussock plants are green, actively growing and not moisture stressed. Optimum time for application is May to October.

Broadacre spray prior to sowing crop or pasture – improved control can occur by removal of dead vegetation, and by encouraging fresh green growth. To do this either burn the paddock 10–12 months prior to spraying, slash or heavily graze two weeks before spraying. Follow critical comments on the label for best results.

Herbicide training is highly recommended for all herbicide users to ensure safe use of chemicals.

Accredited training courses are run by organisations such as ChemCert, Smartrain and TAFE colleges.

Other training courses may be available through state agencies, local councils or non-government organisations.

Spray top to prevent seeding – best results are obtained if applied prior to flowering, mid-August, or prior to seed set in mid-October.

When using glyphosate to selectively remove serrated tussock. Know the lifecycle of the pasture species you want to protect. This will involve thorough inspection of the plant at different parts of the year. Only apply glyphosate when the desirable plants are completely dormant. Get down at pasture level and check—if any green parts are present on the plant then glyphosate will affect it.

Generally for annual pasture species, apply glyphosate to treat serrated tussock after they have set seed. For perennial grass species, apply in winter for summer growing (C_4) grasses, whilst apply in mid-summer for some winter growing (C_3) grasses when they are completely dormant, see page 66 for more information. Always seek advice from an agronomist for your specific situation.

Advantages

- Able to target other weeds at the same time when spot spraying.
- A quick method of killing serrated tussock.
- Nil grazing withholding period.
- When applied accurately, is very effective.

Disadvantages

- Unlikely to affect serrated tussock seed bank levels.
- Broadacre treatments of glyphosate can lead to a monoculture of weeds. Replace the tussock with desirable species to prevent this from occurring.
- Glyphosate is non-selective. Over-spray may open up bare areas, increasing the risk of re-invasion, especially in a dry year.

Glyphosate can provide you with a distinctive picture to see where you have sprayed in the past (Cooma workshop).

Flupropanate

Flupropanate is a slow acting herbicide predominantly absorbed through the roots and also the leaves. It can take 2–12 months to kill the plant, particularly if affected by drought.

Characteristics of flupropanate include:

- A residual action in the soil that prevents or limits the growth of emerging serrated tussock seedlings. Residual life varies depending on soil type and rainfall, but may generally last 2–3 years. Time may be reduced by large rain events or soil movement from flooding. Residual action in soil may allow tolerant desirable pasture species to increase in density, providing good competition for serrated tussock once the residual effect has gone.
- Some selectivity, but may cause non-target damage, particularly to native species. See below for more information.
- A long withholding period for grazing animals which may have large implications for grazing management. Spot application: 14 days following treatment; broadacre application: four months following treatment. Lactating cows and goats must not be grazed in treated areas.



Michael Michelmore

Aerial spraying of flupropanate in the Snowy mountains—before (top) and after (bottom). Note the serrated tussock has returned following treatment; however, there is no other native vegetation left to compete.



Michael Michelmore

Flupropanate applied in certain situations can kill serrated tussock with minimal damage to desirable vegetation.

Selectivity

Many introduced and native grass species are tolerant to flupropanate; however, many are not. Before using flupropanate to control serrated tussock, know the composition of the pasture and how each species may be affected by flupropanate. Using flupropanate, particularly in native pastures, may change its composition. For example, high rates of flupropanate can reduce the levels of weeping grass (*Microlaena stipoides*) and increase of level of red-leg grass (*Bothriochloa macra*).

Flupropanate selectivity is also influenced by the application rate. For example, some plants have a low tolerance at high label rates.

Tolerant species

Introduced pasture species tolerant to low label rates of herbicide (less than 2 L/ha) include phalaris, cocksfoot and tall fescue. While considered 'tolerant', they may be affected by the treatment, but should recover.

Do not sow phalaris, cocksfoot, ryegrass, red, white and subterranean clovers and lucerne into flupropanate treated areas until at least 100 mm of leaching rain has fallen (plant back period).

Native species that are tolerant to flupropanate at the recommended rates include:

- kangaroo grass (*Themeda triandra*)
- red-leg grass (*Bothriochloa macra*)
- poa or silver tussock (*Poa labillardieri*).

Susceptible species

The following species are known to be susceptible to flupropanate:

- weeping grass (*Microlaena stipoides*)
- wallaby grass (*Austrodanthonia* spp.)
- spear grass (*Austrostipa* spp.)
- legumes, particularly young subterranean clover.

Cautions

- Some desirable grasses, such as native species and perennial improved species, subterranean clovers and other annual legumes may be damaged by flupropanate if exposed to the spray or if they germinate and grow before residues have dissipated from the soil.
- Flupropanate effectiveness may alter according to soil type. Flupropanate can become more active in lighter soils (shale/sandy) than heavy soils (clay).
- Resistance to flupropanate has already developed in a few populations of serrated tussock. More information on resistance is given on page 24.
- The residual effects of flupropanate must be carefully managed in your soil. Avoid repeated broadacre spraying that will increase existing residual flupropanate in your soils to levels where large areas of susceptible species are damaged.
- Application of flupropanate on land that contains a high proportion of susceptible species can leave ground bare and exposed to reinvasion.

Suitable for:

- Spot spraying in all situations, particularly when density levels are light and scattered. Spot spraying high density infestations of serrated tussock in native pastures and grasslands may also be effective.
- Broadacre application in introduced pastures due to their greater tolerance levels and ability to recover.
- Wick wipe in pasture, urban and native grassland situations with infestations of a medium to high density.

Application

May be used in spot, broadacre (ground or aerial) and wick wipe applications. If broadacre spraying, the boom sprayer should have an automatic rate controller and should be correctly calibrated. This is particularly critical for aerial application. Always ensure rates are applied according to the label.

Spot spray using a carefully directed spray into the centre of the plant with a low volume knapsack. Specific application at this point will reduce the risk of non-target damage, as flupropanate is largely taken up through the roots.

Apply low label rates in a broadacre application to control serrated tussock seedlings (less than 10 cm high) in an introduced pasture situation.

Flupropanate can be mixed with glyphosate in a spot spray application to provide a quick knockdown while having a residual effect for emerging serrated tussock seedlings. However, glyphosate reduces the effect of flupropanate and should only be added as a marker when absolutely necessary. If quick brown out is wanted close to seeding, just use glyphosate or a mixture of flupropanate and glyphosate.

Flupropanate can decrease its residual activity if the area is burnt after application.

Undertake broadacre applications of flupropanate with care as off target damage to susceptible species may occur, reducing production. Ensure that the contractor uses an automatic rate controller and that this is correctly calibrated

Timing

Spot spray at any time of the year.

Ideally, apply flupropanate during the vegetative stage of growth of serrated tussock to allow sufficient time for herbicide to take effect prior to flowering. This may be at least 3 months before flowering, depending on rainfall.

Advantages

- Residual herbicide will reduce the growth of serrated tussock seedlings for an extended period—up to a number of years under very low rainfall conditions.
- Tolerant desirable species are able to establish and stabilise an area while the tussock degrades.

Disadvantages

- Residual effects may reduce the growth and establishment of the crop or pasture.
- Long withholding period for broadacre applications may be a deterrent due to grazing management issues.
- Application of high label rates of flupropanate may result in a loss of highly productive desirable pasture species.
- Lactating stock must not graze treated areas.

Always ensure equipment is properly calibrated for correct application rates.



Successful application of flupropanate in an introduced pasture situation.

C₃ and C₄ grasses

C₃ and C₄ are terms used to describe the photosynthetic pathway or system that a perennial grass uses. All it means is that some plants are better adapted for winter growth, while others are more adapted for summer growth. This can have implications on the timing of herbicide applications in the control of serrated tussock.

C₃ grasses generally have active growth during winter months and are dormant (do not actively grow) during summer. However there are exceptions to this rule. Weeping grass (*Microlaena stipoides*) and wallaby grass (*Austrodanthonia* spp.) are two native perennial C₃ grasses that are yearlong green species.

Alternatively, C₄ grasses actively grow in summer and are dormant during winter.

This is only a guide of when some grasses have their period of dormancy. It is important to **get to know the lifecycles of the grasses within the pasture**. Herbicide application can then be manipulated for the best possible results, with the least amount of non-target damage. Get down at grass level and thoroughly check the pasture before applying glyphosate. If any green parts are on the plant, they will be affected by herbicide.

Implications for glyphosate application:

- Glyphosate must be applied to actively growing plants to be effective.
- Appropriate timing of glyphosate can be used to protect desirable pasture species—when perennial plants are completely dormant (winter for C₄ grasses and mid-summer when soil moisture is low for C₃ grasses) and after annual grasses have set seed.
- Do not apply glyphosate until pasture has been checked thoroughly and desirable species are completely dormant.
- Do not use glyphosate in a broadacre application where C₄ grasses grow along side C₃ grasses.
- To succeed in rehabilitating an area infested with serrated tussock with glyphosate, there must be adequate densities of desirable back ground pasture species present to fill the 'gap' when the serrated tussock is removed (Verbeek 2007).

Implications for flupropanate application:

- Not recommended for broadacre application on pastures containing high numbers of susceptible plant species—regardless of their lifecycle.
- Do not use flupropanate in a broadacre application if the desirable native vegetation consists predominantly of C₃ native grasses.

Further information may be obtained from an agronomist.

C₃ grasses (winter active) include:

- *Nassella trichotoma* – serrated tussock
- *Nassella neesiana* – Chilean needle grass
- *Phalaris aquatica* – phalaris
- *Dactylis glomerata* – cocksfoot
- *Lolium perenne* – perennial ryegrass
- *Festuca arundinacea* – tall fescue
- *Austrodanthonia* spp. – wallaby grasses (native)
- *Poa labillardierei* – tussock grass (native)
- *Poa sieberiana* – snowgrass (native)
- *Microleana stipoides* – weeping grass (native)
- *Austrostipa* spp. – spear grasses (native)

C₄ grasses (summer active) include:

- *Pennisetum clandestinum* – kikuyu
- *Paspalum dilatatum* – paspalum
- *Sporobolus africanus* – Parramatta grass
- *Themeda triandra* – kangaroo grass (native)
- *Bothriochloa macra* – red grass, red-leg grass (native)

Spot spraying



Charles Grech

Spot spraying.

Herbicides, glyphosate, 2,2-DPA and flupropanate, can be used to spot spray serrated tussock. Individual plants are treated using a knapsack or spray unit with handgun. Spot spraying can be done on foot or on a vehicle. Include in daily farm activities.

When spot spraying:

- only spray the target plant—do not over-spray
- spray every serrated tussock plant you find
- monitor where you spray
- use a coloured marker dye
- control scattered infestations first and work back into denser infestations
- spray at optimum times for best results
- spray with a carefully directed spray to avoid over-spray—stand over the plant for a full view
- limit the areas you plan to spot spray—set achievable goals
- take your time and have regular breaks.

Always follow up treatments with further spot spraying or chipping, as some plants may have been missed and new seedlings will always emerge.

'Spot spraying effective every day' (Bathurst workshop).
Spot spraying—'hard work paid off' (Attwood workshop).



Charles Grech

Using a dye marker can help you see which plants have been treated.

Suitable for:

- All situations.
- Best in light and scattered infestations; however, excellent results have been obtained from diligent spot spraying of medium to high density infestations, when sufficient resources are available.
- An effective follow up treatment.

Application

Application will vary depending upon the chosen chemical. Each chemical has a different mode of action.

- Glyphosate – cover entire plant with herbicide, but not dripping, and apply when the plant is green and actively growing.
- Flupropanate – apply a small amount of herbicide into the centre of each tussock. This may reduce damage to non-target species.

Take your time to ensure treatment of all plants. A few tips are:

- look behind to see if any plants have been missed
- work with the sun behind you so that you are not squinting when looking for plants to treat
- use flags, stakes or fence droppers to help you divide up and mark areas being treated. This may be particularly useful when working in gullies or hilly country
- use a tracker, such as a GPS, in conjunction with a spray marker to indicate spray lines.

Always carefully read and follow all label directions and use correctly calibrated equipment.

Timing

- Flupropanate may be spot sprayed at all times of the year.
- Apply glyphosate when serrated tussock is actively growing and stress free, usually May–October.

Advantages

- Possible to target other weeds at the same time.

Disadvantages

- Can be easy to miss plants, particularly small plants hiding under larger ones.
- Can be labour intensive.
- Non-target damage may occur.

Broadacre spraying



Malcolm Campbell

Aerial spraying can be useful when the area is too extensive to ground boom or the density is too large to spot spray.



Charles Grech

Aerial mis-spray of flupropanate.

Broadacre spraying can be achieved via ground or aerial (helicopter or fixed wing) application. It is important to use the correct herbicide for your situation. Broadacre spraying should not be used in isolation. Know the dominant species within the pasture and their susceptibility to different herbicides. Follow up with competition strategies that focus on enhancing pasture density and ground cover.

Aerial and ground spraying is strictly regulated in Tasmania. Anyone wishing to undertake broadacre spraying of serrated tussock in Tasmania should seek advice from the Department of Primary Industries and Water.

Considerations before broadacre spraying

Selectiveness of the herbicide relies on the correct rate of herbicide per hectare being applied in an even and consistent manner across all vegetation. To achieve this, the sprayer needs to be calibrated and driven accurately at a consistent speed. It is important to:

1. Know the type of paddock you will be driving and consider what speed will be appropriate for the entire area – choose one speed and stay constant, unless using a flow controller.
2. Choose appropriate spray nozzles to suit the ground speed and volume of water to be applied per hectare (refer to the herbicide label). Avoid spray drift by using lower pressures and nozzles (such as air induction nozzles) that produce large droplets. For example, coarse to very coarse classification.
3. Clean filters and check the spray pattern and output of all spray nozzles on the spray boom.
4. Use a method of guidance when driving across the paddock to ensure that strips are not missed or double overlapped. For example, foam marker or GPS systems.
5. Use an automatic rate controller; particularly for aerial application. A rate controller may save you money as you may use less chemical and consequently do less damage to your pasture.

Suitable for:

- Situations where the density of serrated tussock is too high and extensive to effectively conduct spot treatments.

- Ground application on arable land and aerial application on difficult to access terrain. Also useful when the area affected by serrated tussock is so large it is more cost effective to apply herbicide by air.

Application and timing

Correctly calibrate all spray equipment before use, always use clean water and strictly follow all herbicide label directions and rates.

Flupropanate

- Low label rates of flupropanate can be used to selectively kill serrated tussock seedlings in introduced pastures. This should be done in April–August, before the spring flush or December–February when improved C₃ pasture species are completely dormant.
- In steep country, use low label rates of aerially applied flupropanate and higher rates of water.

Warning

- There have been some disastrous events involving aerial spraying of flupropanate, where all species, including desirable natives were destroyed. If using this option, ensure you use a GPS to mark areas treated and flow control equipment. Exercise extreme care and caution.
- Do not broadacre spray native pastures with flupropanate, or other areas, that have susceptible native grasses as the dominant pasture species.

Glyphosate

- Aerial or ground application of glyphosate in pasture or fallow situations prior to sowing crops, fodder crops or new pasture.
 - Removal of all vegetation prior to sowing crop or pasture – apply February to May.
- Spray-topping – use low label rates of glyphosate in a ground or aerial application prior to seed-set (mid-August to mid-October).
- If using in a pasture situation, apply when desirable perennial species are completely dormant. See page 62 for more information.

Advantages

- More economical in large scale infestations.

Disadvantages

- Aerial spraying can be very expensive when using high water rates.

- Success rate depends on the skill levels of the pilot if not using a guidance system.
- High risk of non-target damage.

‘The most critical factor when hiring a contractor or doing broadacre spraying (air or ground) themselves is making sure that the spray equipment has an automatic rate controller and that this is correctly calibrated.’ Alan McKenzie

Wick wiping



Malcolm Campbell

A distinct height difference must occur between the desirable vegetation and serrated tussock.

Wick wiping is a technique that selectively ‘wipes’ the herbicide onto weeds. Equipment can be mounted onto a vehicle or hand-held, and is applied from a ropewick or rotating carpet wiper saturated with concentrated herbicide.

Only use when a distinct height difference occurs between beneficial pasture species and serrated tussock. Always monitor treated areas for small, missed plants and remove by chipping or spot spraying.

Suitable for:

- Removal of large serrated tussock plants in pasture situations.
- Infestations on level ground—wiper height can not be automatically adjusted.

Application

1. Crash graze pastures to reduce the height of all desirable species—serrated tussock should be at least 15 cm taller than the desirable vegetation.

2. Set wiper at a level of 10 cm above the pasture.
3. Always keep wick wiping equipment higher than desirable species.
4. Travel at low speeds, less than 8 km/hr, with two passes of the wiper made in opposite directions.
5. Keep wiper wet, but not dripping, with herbicide at all times.
6. Avoid herbicide dripping onto non-target species.

Timing

- All year. Avoid application in very dry winters.

Advantages

- Minimal damage to desirable vegetation.
- Low risk of off target damage.
- Requires small volumes of herbicide.

Disadvantage

- Only treats large plants, missing small juvenile plants.
- Can be labour intensive.

Spray topping

Spray topping uses low label rates of herbicide to reduce or prevent seed-set in serrated tussock, which may help in reducing the serrated tussock tussock while doing minimal damage to beneficial species. It can be used as a broad acre treatment to stop serrated tussock seeding. It will not kill serrated tussock plants, but will affect them so that they do not flower, or if already in flower will not produce viable seed. However, spray topping will not kill seed once it is already formed on the plant.

Always use with other methods of control such as spot spraying, chipping and grazing management.

Suitable for:

- A short term option only and particularly in pasture situations with medium to high level infestations of serrated tussock.

Application

- Broadacre applications of low rates of glyphosate.
- Low rates of flupropanate may be added to glyphosate to reduce re-invasion from the serrated tussock seedbank.

Timing

- Timing is critical for this method to be effective.
- For glyphosate treat prior to flowering—mid-August to mid-October.
- Always apply herbicide in accordance with label directions.

Advantages

- Reduces seeding.
- Less damaging done to desirable pasture.

Disadvantages

- Does not kill the plant.

Competition

Serrated tussock is a weak competitor as a seedling. Maintaining a healthy ground cover of desirable species is the key for long term management and control. Competition should be made an integral part of any control program.

[In our district] serrated tussock has changed farm management from grazing stock to cropping (Geelong workshop).

Cropping/cultivation



Charles Grech

On arable land, a cereal crop rotation can reduce the serrated tussock seed bank and compete strongly with emerging seedlings.



Peter Fullerton

Brassica forages crops are an alternative to cereal crops.



Charles Grech

Scarified serrated tussock—control was ineffective.

Cultivation on its own is a short term method to control serrated tussock and reduce the seed bank. For long term control, sow cultivated areas to crop or pasture. Cropping can be an alternative to grazing, provide an alternative source of income and reduce the soil seed bank.

Prior to sowing a crop, a soil test should be conducted to determine fertiliser, lime and gypsum requirements. If suitable, land can be continually cropped or sown to pasture after a couple years of cropping rotations.

Specific advice on suitable crops for your location may be obtained from your local agronomist. Suitable cereal crops may include wheat, triticale and oats; summer forage crops may include brassicas.

Suitable for:

- Arable, agricultural land, where the pasture is rundown and requires renovation.

Application:

- Prepare paddock to be cultivated by:
 - heavy grazing, burning or slashing to remove excess plant litter in heavy infestations
 - broadacre application of glyphosate to kill all existing vegetation prior to sowing.

Note:

1. New areas may require high spray inputs to effectively kill high densities of serrated tussock.
 2. Do not heavily graze pastures that contain only serrated tussock.
- Use a disc plough, or similar, and plough deep enough for serrated tussock plants to be over turned and broken up. After ploughing, paddocks can be either left to fallow or sown to crop.
 - Prior to sowing crop, apply fertiliser, lime and/or gypsum as per soil test results.
 - Treat fence lines and any other area that are not able to be cultivated by spot spraying with glyphosate or flupropanate.
 - Once crops have emerged, spot spray any emerging serrated tussock seedlings with glyphosate.

- If suitable, land may be continually cropped or sown to pasture following two years of cropping rotations.

Specific information such as crop varieties, sowing rates and crop nutrition may be obtained from an agronomist.

Timing

- For winter crops, prepare paddocks to sow in autumn.
- For summer crops, prepare paddocks to sow in spring.
- Time of sowing will vary depending on rainfall.

Advantages

- Continued cultivation kills serrated tussock plants.
- Cropping rotations provide strong competition with emerging serrated tussock seedlings.
- Reduces the serrated tussock seed bank.
- Forage crops may be used in a cropping rotation as grazing feed.
- Cropping may provide income.



Charles Grech



Charles Grech

Don't forget to spot treat fence lines and rocky areas unable to be cropped.

Disadvantages

- Disturbance of the soil caused by ploughing will result in a mass germination of serrated tussock.
- Cropping requires high labour and cost inputs, particularly if changing land-use from solely grazing.
- Ploughing around rocks and obstacles can be a problem as tussock seedlings can remain trapped, causing a re-invasion.
- Cultivation areas still need to be spot treated along fence lines and areas not able to be cultivated.

Warning: Cultivating or cropping native pasture may be illegal depending on federal and state legislation. Do not destroy native pastures by any means unless prior approval has been given by a relevant government authority.

Pasture establishment/renovation

Pasture establishment can be the complete re-sowing of a pasture following a cropping rotation or the renovation of an existing pasture to increase the density of desirable pasture species.

Serrated tussock is very vulnerable at the seedling stage as it is slow growing and susceptible to high competition levels. When there is limited bare ground available and higher competition for water and nutrients, serrated tussock plants have difficulty surviving past the seedling stage. Having a strong, competitive pasture is a long term control measure that targets this feature.

Improving the productivity of land by using fertiliser and introduced pasture species can help reduce the incidence of serrated tussock invading.

Suitable for:

- Introduced pastures that are in a degraded state and require complete re-establishment to be competitive with serrated tussock.
- Mixed native and improved pastures that require the addition of desirable species following treatment of serrated tussock to improve the health and competitive value of the pasture.
- Steep or rocky land with vegetation that requires improvement to be more competitive with serrated tussock. Specialised equipment is required for sowing pasture in these situations.

Application

On arable land, crop paddocks for at least two years before sowing pasture, to reduce the serrated tussock soil seed bank. Information on cropping and cultivation is on page 71.

- If sowing a pasture after cropping, a broadacre application of glyphosate may then be required to remove any emerging weeds before sowing.
- Apply fertiliser, lime and gypsum as required by soil test results. With adequate rainfall, the aim of fertiliser is to provide rapid growth of desirable pasture species, to improve the quality and density of pasture.
- Sow pasture into warm soil that has received adequate moisture to ensure optimal establishment and pasture growth to compete with serrated tussock seedlings.
- Suitable pasture species will vary between regions depending on climate. Possible introduced species may be a mix of perennial grasses, for example, phalaris and cocksfoot with legumes such as subterranean clover.
- Clovers are an important component of a pasture as they provide nitrogen to the grasses and help improve soil fertility.
- Competitive native pasture species include kangaroo grass and poa or silver tussock.

Newly sown pastures established by conventional methods or direct drilled must be locked up for 12 months to allow time for establishment and development. Depending on soil moisture, a quick graze once plants are well anchored can help plants to thicken up and increase in size.

Remove all grazing pressure, including native and pest grazing animals, from establishing pastures. This can be helped by fencing off pastures (with rabbit proof mesh) and conducting feral animal control programs.

To maintain productivity and competitiveness, improved pastures require strategic grazing management, fertilising and spot treatments to control any emerging serrated tussock.

Always seek advice from your agronomist on sowing rates, timing and the most suitable pasture species and cultivars for your area.

In small areas where bare ground has been left as a result of killed serrated tussock plants, re-seeding of pasture species can be achieved by broadcast seeding and fertilising.

Broadcast or aerial application (depending on aspect) of pasture seed and fertiliser onto modified native pastures may be an option. Native seed costs are currently very high and results highly variable, so this may not

be a viable option. Native pasture such as kangaroo grass (*Themeda triandra*) can be very competitive with serrated tussock.

Pastures aerially sown usually take longer to establish and have more variable results compared to ground sown pastures. They also need to be locked up from grazing for the first three spring/summer periods after sowing (Campbell & Vere 1995) to allow establishment of desirable pasture species.

In rocky terrain, specialised all terrain seeding equipment can be used to direct drill pastures.



David McLaren



David McLaren

An all terrain seeder can be useful if wanting to either sow a new pasture or crop on rocky land.

Pasture re-development is crucial for maintaining sufficient competition against tussock (Cooma workshop).

Timing

Depending on location, sow pasture during the autumn/winter period when sufficient soil moisture is available, or spring following sufficient rain. Spring sowing may not be suitable for areas with an annual rainfall of less than 600 mm. Start paddock preparation for pasture establishment in the year prior to planting.

Once pasture has established and at least one year old, flupropanate may be applied at low label rates to remove serrated tussock seedlings.

If flupropanate was used to kill serrated tussock prior to sowing pasture, 100 mm of leaching rainfall (plant back period) must fall prior to sowing pasture species to remove residual from the soil.

Advantages

- A densely growing pasture with good ground cover is crucial for maintaining sufficient competition against serrated tussock.
- Improving pastures may help to increase the carrying capacity and productivity of a property in the long term.

Disadvantages

- Grazing is limited on newly established pastures particularly if they have been aerially sown.

Grazing management

Grazing and pasture management is the total process of ensuring pasture persistence and ground cover, maintaining soil nutrition for growth and organising livestock to make the best use of the pastures grown. It is about managing the frequency (how often the stock are removed) and intensity (how hard and how many) livestock graze pasture (MLA 2008).

Good grazing management is necessary to maintain pasture cover and density to effectively compete with serrated tussock. Total grazing impact includes domestic livestock and both native wildlife and introduced feral grazers.

Serrated tussock seedlings are slow growing and relatively weak competitors; however, if they are able to survive to maturity, they may dominate the grassland indefinitely, requiring active removal. It is cheaper and easier to stop serrated tussock seedlings from establishing.

Suitable for:

- All pastures on all land-uses.

Grazing management is essential in the integrated management of serrated tussock.

Type of grazing animal

Research has shown that the type of animal that is grazed is not of concern; the importance is managing the pasture and ground cover. Some animals are more selective grazers and the grazing habits of different animals should be taken into account when managing the pasture.

All animals will avoid eating serrated tussock if there is more palatable and nutritious feed available. Paddocks need to be properly managed so they remain healthy, vigorous and competitive, and not overgrazed.

Application and timing

Introduced pastures

A mix of perennial and annual, grass and legume species, in a pasture will help provide a strong pasture base to manage.

The density of the pasture is the key. Ideally maintain a ground cover of at least 90–100%, and pasture density of at least 1200 kg DM/ha (about 4 cm high). This will help to reduce the establishment of serrated tussock from the soil seed bank and minimise the chance of new infestations developing from windblown seed.



Peter Fullerton

Example of a competitive introduced pasture with shelterbelt along boundary.

*‘For a dry season pasture should be no less than the depth of a beer can on its side and for a good season, no less than a can standing up’
(Bathurst workshop).*

Focus management on continually improving the quality of pasture by promoting the growth of desirable species that will minimise serrated tussock invasion. Strategic fencing of larger paddocks and rotational grazing of these paddocks are tools that may help to achieve a highly productive and competitive pasture. Doing this will also increase productivity and profits (MLA 2003).

Strategic rotational grazing involves short periods of grazing with high stocking rates, followed by periods of no grazing, allowing the pasture time to rest and for desirable species to grow, set seed and allow seedlings to establish if pasture recruitment has occurred.

'Grazing management, particularly the resting is important.' Rotating livestock allows your paddock to rest in an attempt to build up thicker groundcover (Cooma workshop).

Overgrazing can cause an increase of tussock when competition is reduced (Cooma workshop).

Overgrazing pastures may result in the degradation of desirable species, reduced ground cover and pasture density, and increased risk of serrated tussock invasion. Set stocking places continual pressure on the pasture and bare patches of ground are likely to form as stock heavily graze palatable feed. Rotational grazing allows even pasture recovery of all species, including the more palatable species.

Strategic grazing management must be used as one component of an integrated management plan. Always monitor pastures for serrated tussock seedlings and follow up with spot spraying or chipping.

Newly sown pastures

- Avoid grazing in the first 12 months to allow the pasture time to establish and set seed in its first summer. Only lightly graze if there is enough soil moisture once the new plants are well anchored.
- In the first three years after establishment, lightly graze with periods of rest in the spring/summer period to allow plants to increase in size and become well established.

Established pastures

- Graze pastures until total dry matter is 1200–1500 kg DM/ha (around 4 to 5 cm high) then remove stock from the paddock. Try to maintain a 90–100% ground cover, avoiding bare patches of ground. Constant monitoring of pasture levels is crucial in rotational grazing.
- Summer and autumn are critical periods of time for serrated tussock seedling recruitment and survival. Keep competition levels high at these times.
- Regularly fertilise to maintain pasture productivity and competitiveness.

Source: Vic DPI 2004; Vic DPI 2007; Ayres & Leech 2006.

Even in times of drought always try to maintain ground cover.

Grazing management is a 'shift in managing animals to managing grass.' (Canberra workshop)

Native pastures

Native pastures may contain all native species or a mix of native grasses, subterranean clover and annual grasses—modified native pasture.



Steve Taylor

A competitive native pasture.

Long-term grazing management strategies are essential to encourage the growth of native species. Graze the pasture for short periods of time followed by long periods of rest to allow native grasses to regenerate and set seed (deferred grazing).

The optimum duration of these phases will vary and should be decided on the basis of regular inspection of the pasture and the stock. Pastures should be grazed only if they will recover rapidly. If pastures are not growing in summer they should not be grazed hard, even for short periods.

The optimum density of a native pasture to prevent serrated tussock seedling recruitment is greater than 800 kg of perennial grasses per hectare (pasture about 5 cm high over summer) and 90–100% ground cover. Rotational grazing will help maintain adequate levels of dry matter and ground cover.

Maintaining high levels of cover may be difficult to achieve, so concentrate management on:

- promoting desirable perennial grass content in the critical summer months. This will help to reduce serrated tussock seedling survival over summer and serrated tussock germination the following autumn
- ensuring a desirable proportion of legume (25–30%) persists in the pasture
- ensuring the grazing program contains long, strategically timed rests that coincide with the seeding period of native grasses
- reducing stocking rates in the first year or two to increase the level of desirable pasture species
- allowing pasture to increase in biomass during times of increased soil moisture. Start in spring, when soil moisture levels are adequate for plant growth.

In modified native pastures, regularly fertilise to boost clover growth and rotationally graze to help keep a balance of native grasses. Paddocks managed in this way can become very productive yet sustainable.

Further advice may be obtained from an agronomist. A range of pasture management courses are run by different organisations, see page 89 for more information.

An example of a rotational grazing system one land manager has used is:

- During the spring, two mobs of rotational grazers were on a 7–10 day grazing cycle followed by a period of 6–8 weeks of rest to allow for the native grasses to seed and thicken up.

Source: Badgery et al 2008a; Badgery et al 2008b.

*‘Sheep and bad management, best spreaders I know’
(Canberra workshop).*

Advantages

- Rotational grazing may increase the productivity of a pasture in the long term and improve returns when compared to set stocking (MLA 2003).
- Having a healthy vigorous pasture is more likely to withstand invasion from serrated tussock and other weeds.
- Rotational grazing to maintain a good ground cover with a variety of perennial grass species is also regarded as good soil carbon management which may have positive implications in the future.

Disadvantages

- May require additional labour.
- May need to increase infrastructure, such as fencing and watering points, to gain maximum benefit.

If using herbicide in conjunction with grazing management it is important to observe withholding periods and manage stock around this.

Afforestation



Michael Michelmore

Over time a small plantation of pines can out shade the serrated tussock.



DPI Victoria

Commercial forestry may sometimes be an option for serrated tussock control; however, expert forestry advice is necessary before embarking on such a project.

Areas such as steep gorge country can provide ideal habitat for serrated tussock to dominate. An escarpment dominated by serrated tussock may be a seed source, infecting neighbouring properties. Such areas are difficult to manage due to their aspect and limited options for control.

Planting trees or shrubs, for conservation or commercial purposes, is one way to manage serrated tussock in these areas.

In the long-term, trees and/or shrubs may reduce serrated tussock dominance by:

- providing competition for light and nutrients—a plantation of trees can form a canopy that will help out-shade the tussock, reducing its dominance
- reducing seed spread by altering wind convections.

If commercial farm forestry is not a feasible option, consider retiring the land from all forms of agricultural production and increase the biodiversity value of the property by planting native trees and shrubs, or allow natural regeneration.

Suitable for:

- Steep escarpments and ridges, erosion prone soils, creek valleys and other inaccessible areas.
- Windbreaks or shelterbelts along property boundaries. Plant trees of differing heights to capture seed heads and reduce spread.
- Areas with a large, dense serrated tussock infestation, and where soil fertility and rainfall is not suitable for establishing a strong vigorous pasture.

Application

Tree establishment is a complex procedure. If considering a farm forestry operation, involve a farm forestry adviser in the process as they can advise on site preparation, fertiliser and herbicide requirements, species of tree to plant and ongoing management.

Fence off plantations, or provide protection, from rabbits and grazing stock while trees are establishing. These animals will interfere in growth and development of saplings—stock can remove entire plants, while rabbits eat new growth. Firebreaks will also need to be made.

For re-vegetation purposes on steep terrain, tube stock saplings are generally planted. Aerial sowing of seed (tree species) may be an option; however, results are highly variable. Saplings will also need to be protected from grazing animals such as rabbits and kangaroos until they have established.

Continue to chip or spot spray serrated tussock plants with herbicide until trees have grown and the canopy has closed. Pine plantations can take up to 4 years to suppress the growth of serrated tussock and up to 10 years to kill it (Campbell and Vere 1995).

Always continue with a control program in areas of the property that have not been planted to trees.

Some tree species suitable for plantations include radiata pine, eucalypts such as spotted gum and sugar gum, tea-tree and she-oak. Species to consider as bush regenerators may include self regenerating shrubs such as *Acacia*, *Cassinia* or *Leptospermum* species (Michelmore 2003).



DPI Victoria

Re-vegetating a steep area back to native vegetation may be an option.

Timing

Specific timing will vary between locations depending on rainfall, soil types and topography. When planting trees as a control measure for serrated tussock, always seek specialist advice from a forestry professional.

Advantages

- Plantations may significantly reduce severe serrated tussock infestations.
- Farm forestry can be income producing, turning unproductive land into productive land.
- May double as a windbreak for reduction of serrated seed blowing into or out of the property.
- May provide shelter for habitat, encourage biodiversity and increase the environmental health of a paddock.
- Trees planted in a linear design, at least ten metres in width, may be eligible for future carbon credit schemes.

Disadvantages

- It can take many years for a canopy to develop and suppress the growth of serrated tussock.
- Labour intensive and costly to initiate.
- If trees are harvested, for example, for commercial purposes, there is a risk of serrated tussock invading once the trees are removed.
- Difficult to drag a spot spraying hose amongst the trees.

Reducing spread

Preventing serrated tussock from establishing on your property is the best method of control. Land holders with seeding serrated tussock should also make reasonable efforts to reduce seed spread to neighbouring areas.

As serrated tussock is readily spread by wind across paddock boundaries and to a lesser extent, spread by vehicles, machinery, stock, people and water, it is important to have procedures in place that will help reduce its spread.

The practices outlined are recommended for all land-use situations to prevent or limit the spread of serrated tussock. Prevention is a high priority in serrated tussock control.

Preventative measures are essential to reduce the spread of serrated tussock.

General property hygiene

General property hygiene procedures will reduce serrated tussock, and other weeds, from entering or leaving a property.

Useful strategies to reduce spread include:

- Learn to correctly identify serrated tussock.
- Identify high risk areas of spread onto and within the property and regularly monitor these areas. For example, fence lines, stock yards and holding paddocks.
- Control serrated tussock as soon as it is found.
- Consider using vendor declarations for buying and selling stock feed, or anything that could be contaminated with seed.
- Do not harvest pasture, grain or fodder crops while serrated tussock is in seed.
- Do not allow contractors on site unless they are clean and free from serrated tussock seed.
- Consider using contractors who have a history of being weed-aware.

In all situations, make it a priority to control serrated tussock before flowering. If flowering, or seed-set, has occurred, use the following to help reduce further spread.

- Avoid working in infested areas until serrated tussock has been controlled.
- Minimise movement into and out of infested areas when serrated tussock is in seed.
- Stay on formed tracks and roads.
- Plan to work in clean areas first.

Advantages

- Prevention is easier and cheaper in the long term.
- Able to target a number of weeds, not just serrated tussock.
- Early identification and control leads to better weed management.

Disadvantages

- Can be labour intensive.
- Weeds like serrated tussock may blow in, irrespective of what weed dispersal strategies are implemented.

'There are two types of properties—those that have it and those that are going to get it' (Geelong workshop).

'One thing you have to be careful is your hygiene' (Hobart workshop).

Stock management



Ryan Melville

If stock are suspected of eating seed, quarantine before moving onto clean paddocks.

Stock can spread serrated tussock by:

- transporting seed attached to the coat or by mud in the animals hooves
- eating the plant while in seed, then excreting viable seed.

Stock can be an important source of serrated tussock weed spread and reducing all risks is important.

- Limit the movement of stock from serrated tussock infested areas to clean areas.
- Remove stock from infested paddocks before serrated tussock goes to seed. Note: serrated tussock should not be allowed to seed!
- Place stock in quarantine/holding paddocks if:
 - stock are suspected to be contaminated with seed
 - new stock are entering the property and suspected of being contaminated with weed seed.

If suspected of eating serrated tussock seed, quarantine stock for at least 10 days and provide with clean feed and water. Always use the same holding paddock, monitor for serrated tussock seedlings and control when required.

Advantages

- Infestations initially confined to holding paddocks are easier to eliminate.

Disadvantages

- Extra feed costs if stock are quarantined.

Vehicles/machinery/equipment



DPI Victoria



DPI Victoria

Washing and brushing down machinery and implements following work in known serrated tussock areas is a recommended hygiene practice.

The small seeds and whole seed heads of serrated tussock can get caught in vehicles, machinery and equipment. Vehicles can potentially play a large role in the spread of seed, particularly 4WD vehicles that drive throughout infested paddocks.

Actions to help reduce the risk of spread can include:

- Undertake an accredited vehicle and machinery hygiene training course.
- Plan works. For example:
 - slash before the main flowering period
 - do not harvest crops or cut hay when serrated tussock is in flower and
 - work in clean areas first.
- Consider using preventative equipment such as slasher covers.

Many local councils have clean-down points along roadsides.

- Inspect and where necessary, clean down vehicles, machinery and equipment before leaving an infested site. Dustpan and broom, air compressors and high pressure units are all practical options.
- Areas to pay attention include:
 - on and around wheels, slasher decks and above bash plates
 - air filters, radiators and engine components
 - cabin interiors and ute trays.
- When cleaning down, always:
 - appropriately dispose of any seed collected
 - monitor the clean-down site for emerging serrated tussock seedlings and control as required.

Advantages

- Removes all other weed seeds from vehicle, machinery and equipment.

Disadvantages

- Time consuming.

Accredited vehicle and machinery hygiene courses are available. Contact your local DPI for more information.

Mesh fencing



Malcolm Campbell

Mesh fencing may reduce serrated tussock seed entering an area.

Mesh fencing is a useful tool that captures serrated tussock seed heads, restricting the amount of seed heads blowing between properties or paddocks.

Fence at critical dispersal points such as, boundaries adjoining properties with high levels of serrated tussock, or along the direction of the most prevailing winds.

Fencing may also be incorporated into the overall property management program. For example:

- divide into paddocks for rotational grazing
- separate land-uses that require different management
- may assist in the control of pest animals, such as rabbits.

Regularly check fence lines and spot treat.

Suitable for:

- All situations; except very steep areas.
- Particularly useful where a distinctive difference occurs between a hard-to-manage patch of seeding serrated tussock and an adjacent 'easier-to-manage' area.

Timing

- Erect fences at any time of the year.

Advantages

- May reduce that amount of serrated tussock seed entering or leaving a property.
- Can act as a barrier to other pests such as rabbits and foxes.
- May be useful for stock and grazing management.

Disadvantages

- Costly in the short term.
- Requires regular maintenance.
- Does not actively control or reduce serrated tussock infestations.
- A number of seeds may still blow over the fence.

Incorporate fencing strategies into your overall management program (Geelong workshop).

Shelterbelts/windbreaks



Charles Grech

Shelterbelts planted along property or paddock boundaries can help to reduce an influx of airborne seed.

Shelterbelts and windbreaks are alternatives to fencing as a physical barrier to catch wind blown serrated tussock seed heads.

Tree barriers may be used along property or paddock boundaries, or along ridgelines of steep terrain. The type of tree planted is important so that seed heads are trapped and restricted from blowing over. A windbreak that contains trees with a range of heights is beneficial.

Examples of trees to plant include eucalypt, pine, tea-tree and she-oak.

Windbreaks may not always meet their purpose. Their efficiency is dependant on the density of serrated tussock both up-wind and down-wind, and density and height of the trees. Windbreaks provide a wide range of benefits to agriculture, environment, and amenity. Consider these benefits before planting a windbreak solely for serrated tussock control.

Suitable for:

- All land-use categories.
- May be particularly beneficial in areas such as steep areas, erosion prone soils, rocky country and valleys.



Peter Fullerton

Radiata pines can be useful shelterbelts, as well as providing a dense canopy to 'shade out' serrated tussock.

Timing

Generally planted during winter; however, successful establishment of trees requires planning and advice from a forestry specialist.

Advantages

- A long term, proactive control method.
- May reduce wind induced soil erosion.
- May reduce wind induced damage to pasture and crops, including sand abrasion.
- A wide windbreak (more than 10 m) may qualify for possible future carbon credit schemes.

Disadvantages

- Takes many years for trees to grow to the stage required to effectively catch seed heads.
- May take up valuable pasture or crop space.
- May provide competition with pasture or crop within short distance of windbreak.
- Initial set up can be labour intensive and costly.
- Control of serrated tussock amongst trees may be difficult.

Slashing/mowing



DPI Victoria

A roadside slasher taking part in a weed spread prevention washdown project.

Slashing involves cutting serrated tussock plants to a height just above ground level using a slasher, mower implement or brushcutter.

A short term control method that may be used to delay seed-set in serrated tussock plants. Slashing stimulates the growth of the serrated tussock plants and must be used in combination with herbicide application. Only use as a last resort to reduce the amount of seed formed if unable to use other control methods prior to flowering.

For roadside managers slashing areas of serrated tussock, it is important that:

- slashing is conducted prior to flowering
- machinery is cleaned down at specified clean down points
- serrated tussock infestations on roadsides and public reserves are mapped and monitored
- weed free 'clean' areas are slashed first and serrated tussock infested areas are slashed last
- operators are trained in machinery hygiene procedures and serrated tussock identification
- tools that help reduce machinery contamination are used, such as slasher covers.

Cautions

- A seed head will still generate if slashing is conducted too early.
- Slashing equipment may become a vector for spreading seeds if slashed when serrated tussock seed is present. Machinery hygiene is critical in preventing spread.
- Not considered a control technique for compliance purposes.

Suitable for:

- Roadsides and other urban situations to reduce grass biomass and serrated tussock seed-set.
- Removal of excess dry matter when preparing a paddock for sowing a crop or pasture.
- If flupropanate was applied too late in the season, serrated tussock may still produce viable seed. Slash prior to flowering to prevent seed head development. This will still give flupropanate residual control into the next season.
- Reduction of plant biomass in the fire season.

Do not harvest slashed serrated tussock material for fodder conservation (hay). Serrated tussock is a declared noxious weed throughout all of Australia and cannot be sold or knowingly transported. As such, if serrated tussock is inadvertently harvested for fodder, the hay bales must not leave the property or be sold. Baling hay in paddocks with seeding serrated tussock is strongly discouraged.

Timing

- To prevent seed-set—slash in late winter/early spring prior to flowering. If slashed at flowering, prior to the seed head forming, there is a risk of some seed contaminating machinery. Machinery hygiene procedures are a must.
- To prepare a paddock to sow a crop or pasture—slash in winter or early spring.
- To reduce fire risk—slash at any time, but DO NOT slash when serrated tussock is in seed.

Advantages

- May limit seed production if conducted at the right time of the year.
- May reduce fire risk during summer months.
- Limited soil disturbance.

Disadvantages

- Will not always prevent seeding in a current season—only delay it.
- Does not kill the plant.
- Will not reduce the size of the serrated tussock population.
- Can stimulate serrated tussock growth.
- May increase the spread of serrated tussock seed if precautions are not taken.

Biological control

What is biological control?

Biological control is a long-term management option that uses the natural enemies of a weed, such as insects (moths, beetles) or fungi (rusts, smuts), imported from the weeds country of origin, to slowly reduce its density in Australia over time.

Biological control is not a silver bullet. A biological control program may take years or decades to become established and will never eradicate the weed. Instead, it may reduce the weeds competitiveness and limit its impact.

The process of finding a biological control agent is long, with no guarantees of success. Before a potential agent can be released, it must be

stringently tested to ensure it does not attack native species that are related to or similar to the target species. For serrated tussock, species such as spear grasses (*Austrostipa* spp.) and beneficial introduced grasses (phalaris and perennial rye grass) are among many species that have to be tested.

No biological control agents are currently available for serrated tussock in Australia.

Potential for serrated tussock biological control in Australia.

Serrated tussock was declared a target for biological control in 1999. Previous work had determined that insects were not sufficiently host specific for biological control of serrated tussock. A group of organisations (NSW Shires, Meat and Livestock Association, State Governments, Federal Government) have funded the exploration and testing of potential pathogens for biological control agents of serrated tussock found in Argentina and South America.

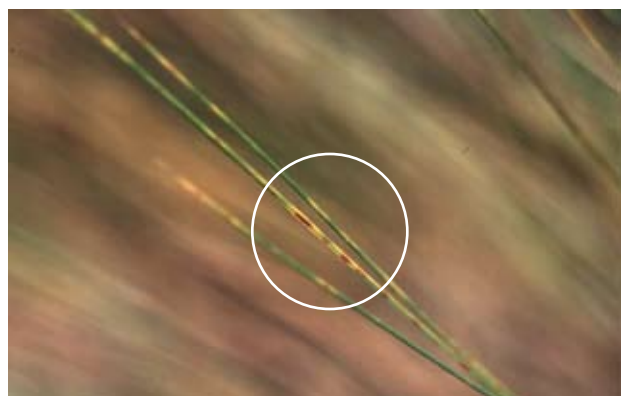
Three potential agents have been identified and tested to date. Unfortunately, none of these pathogens look like a suitable candidate for biological control of serrated tussock in Australia.

1. A rust fungus, *Puccinia nassellae*, was identified attacking serrated tussock in Argentina and in some instances, was observed killing plants. However, due to issues of its host specificity, mass rearing and uncertainties of its life cycle, it is unlikely that this rust fungus will be progressed as a biological control agent.



Freda Anderson

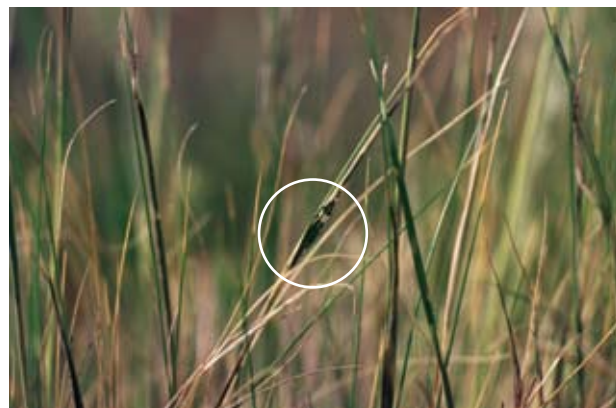
A dead serrated tussock infected with the rust *Puccinia nassellae*.



Freda Anderson

Close up of rust *Puccinia nassellae* infecting some serrated tussock leaves in Argentina.

2. A smut is a fungus that destroys the plants seeds—mostly infecting the plant at seed germination or during the seedling stage. It does not kill the plant, but prevents it from reproducing. A smut infecting serrated tussock, *Ustilago* spp., was found in isolated populations in Argentina. Attempts at culturing this smut have been largely unsuccessful to date, and only three plants of more than 500 inoculated with the smut, became infected. Further research is required to progress this potential biological control agent.



Freda Anderson

The serrated tussock smut, *Ustilago* spp. preventing seed production. The arrow points to millions of dust like smut spores spilling out of the serrated tussock reproductive shoots.

3. A *Corticium* spp. fungus has been identified killing serrated tussock plants in Argentina. It is a soil borne fungus that rots the crowns and roots of serrated tussock. It has not been possible to culture this pathogen making it an unlikely biological control candidate.



Freda Anderson

The serrated tussock *Corticium* spp. fungus infecting the roots.

An observation made in Argentina by scientists is that they rarely see serrated tussock seedlings, suggesting that a potential area of investigation is the serrated tussock seed bank and its associated soil pathogens.

If land managers observe serrated tussock plants dieing or sick for no apparent reason, it is important they report this to their local weeds officer.



Section 5

Case studies

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Changing land-use manages serrated tussock problem

Summary

Robert Hyles has thrown almost every technique possible at controlling serrated tussock on his farm on the southern highlands of NSW. As a result, he has not only reduced the tussock problem, but also broadened his farming enterprise.

The problem

“Woodlands”, situated in the southern highlands, and straddling the NSW–ACT border, is a fifth generation merino sheep (ewes and wethers) grazing enterprise. The annual rainfall averages 635 mm, though drought has been a factor for the past seven years.

Like many properties in the region, it had been increasingly invaded by serrated tussock for over forty years. Initially the tussock was predominantly on the eastern aspect of the property’s hilly country—probably established from seed borne on prevailing westerly winds.

This less fertile, hilly country was traditionally where the wethers grazed. Their grazing created bare patches on the ground, which provided ideal conditions for the establishment of serrated tussock. Gradually the weed spread and thickened.

In the 1980s, the Hyles were ordered by the local council to aerial spray approximately 50 ha of the hills with flupropanate at 2 L/ha to control serrated tussock. According to Robert, the exercise was a “disaster”. It certainly killed the serrated tussock but it also decimated the native grasses and serrated tussock quickly re-established itself. Native grasses that regrew were quickly selectively grazed out by the sheep. The problem became worse than ever.

Robert implemented a range of strategies from spraying to fencing to grazing management and plantations, but initially he did not have a strategy aimed at longer-term control.

In 1999, circumstances arose which motivated him to take a more planned approach to serrated tussock control. He noted that: “The first thing is to admit we have a problem.”

While implementing his strategy for serrated tussock control, Robert was faced with a further problem. In 2004, the Department of Defence compulsorily acquired 200 ha of his property,

Key messages

- Creatively implementing serrated tussock control techniques can mean that some of the techniques are a means for more diversified farm income.
- Active pasture management can mean that serrated tussock is out-competed by desirable grasses.
- There can be significant advantages in considering serrated tussock control as part of the whole farm enterprise.

reducing its size to 1414 ha freehold and 400 ha leasehold. The acquisition process caused delays in the implementation of some of Robert’s plans for serrated tussock control.

The approach

Robert realised early that no one approach would be successful to effectively control serrated tussock. He employs a range of control methods, some conventional and some more innovative. Robert has also sought, and gained, significant assistance from various programs and initiatives to implement his control approaches, especially once he was selected to become a participant in a pioneer project for farmers to sell environment services (the ESS scheme).

What has been done

Spraying: Robert has various large and smaller spray units for herbicide application to serrated tussock. He has adapted a quick spray unit to enable it to be simultaneously used by one to ten sprayers. He has also adapted spray units to fit on motorbikes usually used for mustering sheep. The rider can simply spray patches of tussock while engaged in mustering. He employs family, contractors, Green Corp teams and others to help with large scale serrated tussock spraying exercises.

Hand pulling: All farm vehicles are equipped with a small mattock, which the rider/driver can use to remove tussock. Alternatively, everyone is encouraged to simply pull single plants out by hand—best in bare ground, gravel, under trees or after rain.

Pine plantations: Using a bulldozer, Robert ripped and mounded the area that had previously been aerial sprayed and planted it with pine seedlings at a density of 1000 per hectare. His motivation for planting the trees is summed up in the statement: “I realise that there are areas that I’ll never beat the serrated tussock, that’s why I plant trees.”

Establishment of native trees: Robert decided to plant native trees, or regenerate native trees and understorey species, on about 290 ha of his land. Depending on their location, the trees act as wildlife corridors between existing vegetation remnants, firebreaks or shelterbelts. Greening Australia direct seeded the more easily accessible areas of the property, using a Roden III device. Robert seeded the more intractable areas using a ground ripper and seeder he designed and pulled behind a tractor. He also designed and used a simple hand seeder for use in steep rocky areas. (He subsequently patented and sold the idea to a retailer).

She oak planting: On an 8 ha eroded base of a hill that also contained serrated tussock, Robert established a commercial plantation of *Casuarina cunninghamii*, planting seedlings into ripped and mounded rows using Pottiputki planters.

Hybrid eucalypts: In a 0.5 ha salt scald, he established a commercial plantation of “Saltgrow” hybrid eucalyptus. He planted the seedlings into ripped and mounded rows by spade.

Pasture trials: Robert conducted a pasture trial in a 10 ha paddock where a mother-lode of serrated tussock existed. In the first two years, he sowed winter wheat as a fodder crop followed by a phalaris/clover pasture. Using a commercial spreader he applied superphosphate (plus molybdenum) to the paddock over intervals of four years and ordinary (single) superphosphate in intervening years. He also locked the paddock up periodically to allow the pasture to go to seed. In other paddocks he spread sewage ash at up to five tons per hectare (containing 60% lime and 8% phosphorus—some of which is locked up and released over time). Robert harvests his own phalaris seed and uses it to sow into thinning existing pastures. Such practices can increase the competitive edge of the pasture against serrated tussock.



Strategic use of trees for serrated tussock management in a steep difficult landscape.

Rotational Grazing: Robert considers that it is important to graze pastures to maintain them. But it is equally important not to overgraze. He has implemented a rotational grazing system that allows desirable grasses to recover and 'thicken up'. He uses set stock grazing only during specific periods, such as joining. He "locks up" some of the paddocks on the hilly country during the summer, utilising the feed that has come up in following winter. He allows the phalaris based pastures to be heavily grazed through spring to utilize the growing green feed while delaying seed set. He spot sprays or chips out all emerging serrated tussock plants in pastures used for rotational grazing.

Results

The strategies for pasture management and the use of rotational grazing have yielded pleasing results. Pastures are thicker, resulting in more groundcover for stock in the long-term and more competition for the serrated tussock.

Robert is especially pleased with the results from his 10 ha trial site. When he rested the paddock and allowed it to go to seed, the phalaris-clover pasture competed effectively with emerging serrated tussock. Only large tussock plants survived which were controllable with spot spraying using glyphosate or chipping. Robert's on-farm trials and results received second prize in a competition held by The Grassland Society of NSW.

The western hills that were not aerially sprayed, have not been grazed with stock for five years to allow direct seeded native trees to establish. The native grasses have thrived during this time.

Robert's rotational grazing regime has been successful. Grasses have thickened up as expected, and emerging serrated tussock plants are being out-competed.

The compulsory acquisition of his land by the Department of Defence caused delays in the ripping and mounding of areas targeted for pine planting, resulting in the loss of a significant number of seedlings and the planting of more than 10,000 new seedlings in the following year. The best of the planted trees are now more than two meters high and growing well. These older pines (planted 1994–1999) seem to be having the desired effect of shading out the serrated tussock with fewer tussock plants setting seed.

The native seedlings planted by Greening Australia have suffered over five years of drought. However, those areas ripped and seeded using the hand seeder are showing a healthy growth of trees. The she-oaks and saltgrow eucalyptus are also growing well.

The future

Robert notes that the most significant lessons learnt over the past few years have been to do with how to value the whole farming enterprise. Robert notes: "My financial focus has sharpened. I am deeply involved in valuing our losses (and gains)...and how to value change such as the impact of the sheep reduction due to acquisition; valuing the cost of poor preparation (late ripping for pines) and valuing standing forest trees."

Robert plans to continue maximising his grazing management and increasing his knowledge on serrated tussock management by attending further field days. He comments: "You need to spend money in the right year on the right things to make money". However, he now believes it is time to consolidate and assess the full impact of his strategies to date.

Case Study 2

Pasture management

Summary

Serrated tussock was gradually degrading pastures on the Alstons' Victorian property. Various ad hoc attempts at control had failed in the past so the Alstons implemented a more strategic approach to the weed's control, utilising approaches that ranged from herbicide use, cropping, fire and shelterbelts to reduce seed spread. Although they have achieved significant success, the Alstons know their control regime must continue in the long-term.

The problem

Tid and Sally Alston suspected there was a problem in the late 1980s when they first spotted the serrated tussock plants growing in a 16 ha section of their 400 ha property in Oaklands Junction, Victoria. "We tried to get the plant identified, but the person we asked misidentified it. By the time we found out what it really was the paddock was heavily infested." The situation became worse in 1992 during a very dry year when there was low pasture competition. The tussock spread rapidly.

They realised that to control the weed they needed to think strategically.

The approach

Traditionally, the Alstons' primary enterprise was prime lambs with a head of 400–800 breeding ewes and 400 weaners, Merino/Border Leicester cross. To control the serrated tussock, the

Key messages

- A range of strategies for controlling serrated tussock is necessary.
- Follow up and vigilance is necessary when controlling serrated tussock.

Alstons began to rely more heavily on cropping as well as spraying herbicides, burning and shelterbelt plantings. They are precise about timing activities, and mapping and monitoring results.

What has been done

Cropping: The Alstons used glyphosate to kill all vegetation in the originally infested paddock. They then spread pig manure to increase the soil's fertility and planted a series of crops—barley, oats and summer rape—before returning it to a phalaris based pasture.

They decided to turn the flat, arable paddocks on their land, about 160 ha, to continuous cropping, working with a share farmer to direct drill a variety of cereal and oil crops: wheat, canola and triticale. The Alstons vigilantly removed all serrated tussock from unsown edges and fence lines of the cropped paddocks.



Charles Grech

Use of cropping in flat arable paddocks has been a very successful serrated tussock management tool. Care must be taken to control serrated tussock along fence lines and unsown edges.

Pasture management: The Alstons use a combination of rotational grazing and herbicide application to control serrated tussock in their pasture. They rotate sheep through the paddocks, allowing them to stay on a pasture until the less palatable tussock becomes more visible. They either spot spray or chip out single tussock plants: “We always keep a spray pack and mattock on our farm vehicles so we can get to the single plants.”

On paddocks with denser infestations of serrated tussock, Tid and Sally originally attempted spot spraying but the exercise was too costly and time consuming. They now employ a contractor with a boom spray equipped tractor that uses a GPS guidance and mapping system to ensure accurate application. They have trialled using flupropanate alone as well as a mixture of flupropanate and glyphosate. They spot spray plants missed by the boom sprayer using flupropanate mixed with a marker dye.

In addition, every three years—when fire restrictions allow—they burn paddocks with native pastures.

In 2006, the Alstons had the more inaccessible areas of their property aerial sprayed with flupropanate.

Shelterbelts: Tid and Sally have increased the size and density of existing exotic (pines and cypresses) and native trees shelterbelts and firebreaks to help prevent the spread of serrated tussock.



Charles Grech

Shelterbelts and firebreaks have been very successful in reducing serrated tussock seed spread.

Results

Cropping: Cropping is proving an effective method of controlling serrated tussock. The direct-drilling method rips small emerging tussock from the ground and the crop further provides strong competition against tussock re-emergence.

Pasture management: Rotational grazing in the northern, originally heavily infested paddock has been successful. It now has a strong, competitive pasture cover.

Grazing sheep in the more lightly tussock-infested paddocks is also proving a useful technique

for helping to control the weed as long as the sheep are not allowed to overgraze. The grazing stimulates the growth of plants that compete with the serrated tussock.

In addition, Tid and Sally are pleased with the results of periodically burning paddocks with native grass cover; desirable pasture species recover well after a fire and are able to out-compete emerging serrated tussock.

The Alstons have learnt a number of lessons regarding herbicide application on pastures:

- Timing of large scale applications is important. For example, if they fail to consider the slow rate of action and withholding period of flupropanate, spring pasture that could otherwise be utilised by sheep may go rank. Spraying, therefore, has to be considered as part of the overall grazing plan.
- Using flupropanate alone rather than a mixture of glyphosate and flupropanate in the large scale spraying exercises seemed to have the best effect. Using the herbicides mixed killed both serrated tussock and desirable plant species that do not always recover well especially if the following season is dry. A flupropanate only application did result in the loss of some desirable pasture species but not as severely.
- Aerial spraying produces mixed results. It was a quick way of covering a large inaccessible area in a short period. However: it was expensive due to the need for high water rates; timing of the spraying was restricted to contractor availability; there were logistical issues to overcome with the need to obtain flight path clearance and permits for chemical mixes; and the flupropanate application had the desired effect of slowly killing serrated tussock growth but also affected surrounding desirable species, resulting in less competition and the emergence of saffron thistles.

Shelterbelts: The shelterbelts and firebreaks have restricted the spread of serrated tussock seed, with cypress being the most effective species in catching and suppressing seed spread.

The future

The Alstons believe that their strategy is working. Where possible, they will probably crop the paddocks that have re-emerging tussock to reduce tussock seed stock in the soil. They realise they will always have to control emerging weeds, whether tussock or thistles. The mattock and the spray pack will continue to be carried on their farm vehicles: “It’s an ongoing thing.”

Case Study 3

Controlling serrated tussock without the use of herbicides

Summary

Controlling serrated tussock without the help of herbicides brings special challenges but is not impossible. This case study describes a number of techniques Victorian organic farmers Len and Geoff Menzel used with quite a degree of success. Techniques include: increasing the fertility of the soil, using rock and tree breaks to catch seed, smothering and shading out seedlings, increasing biodiversity, using crops and rotational grazing.

The problem

Len and Geoff Menzel bought their 365 ha Victorian property near Geelong, Victoria in 1987 and have worked it to ensure organic certification for their produce. In 1990 they discovered serrated tussock in their west paddock, a 65 ha block bordered by a rock fence.

The serrated tussock grew initially along the rock fence, which caught seed borne on the prevailing north-westerly winds. The weed then ballooned in through a gateway spreading quickly over the course of three years to cover more than 60% of the paddock.

Len and Geoff were faced with a number of problems: initially they did not know what the weed was; as organic farmers, their option to use herbicides as a means of control was limited; cultivating the paddocks with plants to out-compete serrated tussock would not be successful until full scale serrated tussock community action was enacted to reduce reinvasion by seed rain.

Approach to the problem

Len and Geoff decided that the key to controlling serrated tussock was to control “seed set”. They decided on an integrated approach to management, making immediate goals and longer term ones—if possible they would gain neighbour involvement.

In the short term their aim was to halt the spread of the weed and then gradually reduce its level of infestation. They wanted to at least achieve a level of infestation where serrated tussock did not dictate how the western paddock was worked and could be managed by hand chipping out individual plants.

In the long-term Len and Geoff aimed to have zero serrated tussock on their land.

Key messages

- Stopping seed set of serrated tussock requires an integrated approach.
- Attention to detail when implementing the strategy is important.
- Maintaining good ground cover vegetation is essential to discourage serrated tussock from emerging.
- Clever strategies for controlling serrated tussock may have unexpected positive benefits for farm profitability.

What has been done?

Cropping: At the beginning of their management regime, Len and Geoff removed sheep from the western paddocks most susceptible to serrated tussock infestation cultivated the land and sowed it with linseed and, in rotation, spelt wheat. To keep up the level of soil fertility, they under-sowed with triticale and clover.

Len cultivates meticulously, noting that: “If you drive too wide with a combine, you can create more room for other weeds to come up.”

Rotational grazing: When cropping seems to have substantially controlled serrated tussock, Len and Geoff rotationally graze a herd of sheep through three paddocks. Then, if the serrated tussock re-invades, they remove the sheep and re-crop the invaded paddock.

Buffer zones: To slow seed spread into their land, Len and Geoff have set up a number of buffers, using both rock breaks and plantations.

To make the land more amenable to cultivation, they initially bulldozed rocks into rows. Then in 1990 moved the rocks from the western and eastern boundaries further into the paddocks to form rock breaks. These rock breaks are between 400 m to 1000 m long and approximately 60 m apart.

Along the three kilometre western boundary of the paddock they also planted three rows of pines and then a row of eucalypts. They planted each tree in the row at about three-and-a-half meter spacings. The width of the four rows is about fifteen meters.



Len Menzel

Shelterbelts and strategic placement of rock barriers to protect cropped paddocks from serrated tussock invasion.

Biodiversity: The local Landcare group helped Len and Geoff design plantations within the property that feature native trees and shrubs at various heights to alter wind patterns, and increase soil health and biodiversity. Len and Geoff do carefully spot spray small infestations of serrated tussock within these plantations using glyphosate with an added colouring dye to increase visibility. As these areas are isolated from the cropping/grazing areas, it does not affect organic certification.

Mulching: To control serrated tussock caught by the rock breaks, Len and Geoff push linseed straw/stubble left after harvesting across the rocks to 'smother' emerging tussock seedlings. "You can push the stubble from your header onto the rocks with the help of stick rakes or wheel rakes."

Before the plantation buffer zones were established, the amount of tussock was significant, but over the course of several years, it became clear that the plantations worked well to stop the spread of seed.

What has been the result?

Len and Geoff believe that their short term goals have now been achieved. The pine plantations along the western side of the property have been particularly effective in catching seed heads from neighbouring properties. They have also found that linseed has proven particularly successful as an effective crop for cultivating out serrated tussock.

Future plans

The search for alternatives to conventional herbicide use to control serrated tussock is ongoing. Len and Geoff are considering options such as increasing the number of plantations, using organic products - pine oil or vinegar to control serrated tussock, using barley as a break crop to smother serrated tussock, and increasing soil fertility. Whatever management strategy they use, they will attempt to ensure that each technique simultaneously fulfil a number of functions, such as increasing biodiversity or by potentially providing further income for the farm through a carbon credit scheme should this become a reality for farmers in the future.

"To think organic, you have to think differently."



Len Menzel

Linseed mulch is used to smother serrated tussock around rocky outcrops and other difficult locations on the property.

Case Study 4

Tackling serrated tussock on steep intractable land

Summary

The strategic use of herbicides is a particularly useful strategy when controlling serrated tussock on steep intractable land. However, how and which herbicides are applied depends on the desired outcomes and on the level of off target damage the land manager decides to tolerate. This case study outlines the techniques and concerns of two categories of land managers. The first category are land managers concerned with maintaining native species biodiversity while attempting to control serrated tussock. The second category of land managers are those motivated to control serrated tussock to maintain the profitability of their land.

The problem

Serrated tussock is difficult enough to control on accessible land, but in steep, rocky or deeply rutted landscapes, the problem is even worse. Not only are these areas difficult to access, they usually have the naturally sparse grass cover associated with shallow soil or low fertility that make them susceptible to serrated tussock infestations. Failure to manage the weed on intractable land, however, compounds management issues on more accessible and arable lands because of reinfestation by seed blowing in from unmanaged areas.

Some of the most spectacular and highly visited public reserves in Australia feature steep and difficult terrain. Staff from the Parks and Wildlife Group of the NSW Department of Environment and Climate Change (DECC) know only too well the problems of trying to manage serrated tussock in such landscapes. For them, there is an additional complication that they must control the tussock while at the same time ensuring they preserve native vegetation. These difficult areas are frequently inaccessible even to the 4WD and quad bike spray units DECC usually use.

Steep and intractable land is also a feature of many privately held properties, such as the one owned by John Hyles from the ACT. He has a paddock bordering a 913 m escarpment with a 200 m variation in elevation. Several years ago, 65 ha in the escarpment paddock had a monoculture of serrated tussock, with 10 ha almost inaccessible country. Seed from serrated tussock in the inaccessible area continually reinfested John's property. Unlike staff from DECC, John's primary concern is to run a

Key messages

- Both vegetation type and terrain dictate which serrated tussock control techniques are most appropriate.
- Regardless of method of application, accuracy of herbicide application and application rate are vital. This is especially the case when using aerial spraying.
- Regardless of techniques used for control, it is important to ensure that areas cleared of serrated tussock are revegetated.
- Aerial application of label rate flupropanate may be appropriate and cost effective for control of serrated tussock in steep intractable land dominated by exotic grass species. It is not appropriate for areas dominated by native grass species.
- In some situations, unproductive farming land infested with serrated tussock should be returned to native bushland.

profitable agricultural enterprises rather than manage for the conservation of native fauna and flora.

The approaches

Spot spraying: The method used by DECC on steep intractable land is application of herbicide from spray units mounted on 6WD Polaris Rangers. These vehicles have a lower centre of gravity than a quad bike and can cope with steeper slopes. DECC mounts Quickspray units with extension hoses up to 100 m long on the Polaris Rangers (more hose lengths can be added if required). Where land is too steep and difficult even for the Polaris Rangers, staff use portable spray units, such as knapsack sprayers, Polaris Rangers are also used to support staff carrying backpack spray equipment by carrying water and other essential equipment.



Nick Jacobs DECC

Polaris ranger used for serrated tussock control in steep intractable land.

Increasing fertility: In 1988, John tried applying Mo-superphosphate (molybdenum added) in tussock infested areas as well as seeding sub clover to increase fertility of the soil. This technique resulted in a reduction of serrated tussock and an improvement in pasture.

Aerial spraying: In the early 1990s, John participated in an aerial spraying exercise with a neighbour. He had about 10 ha of land sprayed using a helicopter, using flupropanate at the rate of 2 L/ha. The unfortunate result was a total kill of grasses and a significant reinfestation of serrated tussock and colonisation by acacias. A subsequent aerial spraying exercise some years later that used a lower flupropanate rate per hectare over ripped paddocks more selectively controlled the serrated tussock.

Revegetation: John revegetates areas that have been cleared of serrated tussock to prevent reinfestation. With the help of Greening Australia, John has now planted 9000 pines (6000 have survived), and direct seeded 24 ha of land on the escarpment with natives including tea tree and wattle.

Some serrated tussock agronomists in the NSW Department of Primary Industries (NSW DPI) advocate the use of tea trees (*Leptospermum* spp.) to provide continuous, competitive cover against serrated tussock on intractable land. “Tea tree is often seen as a problem as it recolonises cleared country,” notes Luke Pope, NSW DPI District Agronomist in Cooma. “However, when the cost of keeping an area clear of serrated tussock is greater than what the land is making, it is best to rest the area from grazing to allow natural or actively planted tea tree to dominate.”

The result

All land managers continue to experiment with different methods of control and agree that there seems to be no permanent solution to the serrated tussock problem in steep intractable land.



Luke Pope

Tea tree being used to out-compete serrated tussock in “difficult” country.

DECC is proud of their achievements in the Merriangaah Nature Reserve. This reserve is part of the Snowy River Area and consists of 5652 ha of steep and intractable land, and flatter country cleared in earlier years for pastoral use. Serrated tussock control efforts have reduced the large infestations that existed within the western boundaries at the time the Reserve was gazetted. “Merriangaah Nature Reserve is an entirely different place to when it was taken over. The major known infestations are under control and further spread into the Reserve or onto neighbouring properties is minimal. In the more open areas there is evidence of healthy competition from native grasses and shrubs,” comments Nick Jacobs from DECC.

All land managers have learnt from past mistakes. They all emphasise the need for continual vigilance against reinfestation, accurate mapping, ensuring that there is good replacement ground cover and the appropriate use of herbicides

In areas where farmers have followed NSW Department of Primary Industries advice of promoting tea tree regrowth, serrated tussock has become less of a problem, reducing the cost and time of controlling the weed. There is also evidence that, after some years, the tea trees dominate and form dense canopies that prevent seeds blowing into areas uninfested by serrated tussock.

The future

“Follow up is the key to success,” says Nick Jacobs. DECC has an annual program in known sites that consists of two to three days of effort to mop up small numbers of mainly single serrated tussock plants. Occasionally staff find previously unknown pockets of infestation, which are then incorporated into a new control regime.

In a recent planning exercise, John formalised his long-term goal to contain the spread of tussock on his farm and, if possible, eliminate the infestation altogether. Depending on the topography and productivity of the land, he will continue to use a range of techniques such as:

- continuing to increase soil fertility using fertilisers such as zinc, gypsum and trace elements to condition the soil and help promote desirable species
- increasing the accuracy of spreading fertiliser through the use of a 4WD tractor using a GPS guiding system
- increasing the biomass cover in conjunction with reducing grazing pressure on the paddock
- strategic fencing for grazing management and animal hygiene
- undertaking strategic burns to reduce serrated tussock seeding and seedbanks.

Council incentive programs

Summary

The problem of managing weed infestations in peri-urban communities is made complex by the interaction of many different factors arising from the proximity of densely settled communities and sparsely settled farming lands. The Victorian municipalities of Melton Shire and the City of Whittlesea have implemented effective but different strategies to manage serrated tussock infestations.

The problem

In the 1990s there was considerable land degradation within Melton Shire. Serrated tussock infestations were particularly severe, with some properties containing little other vegetation. Control of the weed was ad hoc and reinfestation a continuous problem.

The City of Whittlesea, located on Melbourne's northern-fringe, also recognised serrated tussock as a significant problem, although tussock infestations were isolated. Council particularly identified roadside reserves as prime avenues for the spread of serrated tussock. These linear reserves often contain remnant native grassland, which are easily impacted by fragmentation and – due to long borders – the edge-effects of weeds. Responsibility for weed management on urban reserves is often a grey area. Weeds can be left unmanaged, impacting upon roadside safety, vegetation quality, and spreading into conservation zones and rural areas.

What has been done

In the late 1990s, Melton Shire Council decided to implement an innovative Environmental Enhancement Policy (EEP) which included a rebate available to all land holders with properties over two hectares who carry out serrated tussock control works.

To obtain the rebate, a land holder must first lodge a Proposed Works Forms detailing intended works to control serrated tussock. Council officers then visit the property to assess whether the works have been completed. If so, the rebate is given. In addition to inspections, Council officers provide land holders with advice on how to control serrated tussock and other weeds, and pest animals and plants.

Key messages

- Incentive programs are an effective approach to motivating land managers to control serrated tussock.
- Incentive programs alone must be backed by capacity building opportunities and underscored by an understanding of the consequences of non-compliance.
- In addition, it is important that key sources of infestation are continuously and effectively controlled.

The EEP has also focused Council's efforts on maintaining its own reserves, including roadsides, in a weed free (especially serrated tussock free) state.

To further assist rural land owners, Council offers approximately \$100,000 in Green Wedge Grants per year. The basis for these grants is are 1995 National Heritage Trust (NHT) funds provided for three years by the Australian Government to conserve significant environmental features, such as endangered native grasslands.

In one instance, Melton Council purchased a property with a severe serrated tussock infestation that nevertheless contained state and nationally significant flora and fauna, and had geological features worth protecting. The property is situated on a high point in a flat landscape and serrated tussock seed blew each year from the property into the surrounding lands. Council now works with the local Landcare group and Trust for Nature to restore and maintain the site.

In 2005, the City of Whittlesea decided on a strategy to eliminate all serrated tussock infestations within its municipality over five years. Actions taken are:

- **Mapping:** annual weed mapping exercises identify all serrated tussock infestations on roadsides, and public and private properties to provide information for targeted control exercises. In 2007 alone, over 1600 inspections were carried out.



Natasha Baldyga

Urban serrated tussock infestations are being targeted for control.



Natasha Baldyga

Roadside serrated tussock control.

- **Roadside reserves:** council invests considerable resources to control serrated tussock on its own roadsides and nature strips. In addition, it utilises Vic Roads Priority Weed Control Funding to manage arterial road reserves. Council employs only qualified environmental weed control contractors who specialise in grassy weed identification and control for these weeds.
- **Incentive programs for land holders:** council contacts land managers with serrated tussock infestations to ensure they are aware of the infestations then provides these land managers with information about serrated tussock, its potentially adverse impacts and the legal requirement for land owners to control the weed. Council refers those few land managers who do not take action to the Department of Primary Industries, which can require compliance under the Catchment and Land Protection Act 1994.
- **Sustainable Land Management Rebate Scheme:** council introduced this scheme in 2005 to further encourage land holders to implement sustainable land management practices, including weed control. Currently there are in excess of 90 properties involved in this voluntary scheme.

- **Raising the public profile of serrated tussock:** council uses media articles and letters to land owners to increase community knowledge about the serrated tussock, making it known that council considers it to be the number one priority weed to control. As a result, members of the community regularly notify council about areas or properties with serrated tussock.

The result and future plans

Both Councils continue to update and make minor changes to their programs. Melton Council increasingly streamlines its EEP process and plans to dedicate additional staff resources to the scheme to help land holders achieve their objectives under the program. In addition, Melton Council will seek extra funding to enable sensitive weed control on sites holding high biodiversity values. A survey of 400 rural properties in Melton in late 2005 found that 86% of land holders agreed that the EEP had been an important factor in reducing the amount and severity of weed infestation in the Shire. In addition 93% of the surveyed land holders supported the continuation of the EEP. Council spends approximately \$2m on rebates each year to support EEP, but estimates the scheme has stimulated approximately \$2.5m per year of land holder investments.

Three years after The City of Whittlesea's strategy began, mature serrated tussock plants have become a rare sight along linear reserves. Only two roadsides, together measuring approximately 2.6 km, have infestations that require continuous and substantial eradication works. All other roadsides and nature strips only require annual monitoring and spot spraying of seedlings. Encouragingly, land owners acknowledge that there has been a noticeable difference on roadside weed infestations, which in turn is reducing the weed burden on private lands.

The City of Whittlesea plans to build on its current program by implementing new initiatives, including a Pest Plant Local Laws compliance program for all land holders. In addition, Council will be developing a machinery hygiene policy, which will include training for roadside management staff on how to prevent accidental weed spread along linear reserves.

On a broader scale, the City of Whittlesea is committed to the Northern Alliance Serrated Tussock Initiative (NASTI), which comprises municipalities within the northern reaches of greater Melbourne, who work in partnership with the Department of Primary Industries. The alliance aims to develop and implement a coordinated, regional approach to managing serrated tussock.

Case Study 6

Cooperative approach between land managers and local government

Summary

In the Snowy River Shire Council area, a diverse group of land managers have demonstrated that pooling resources, knowledge and goodwill returns significant gains when controlling serrated tussock across a large area. Their efforts began in 1998 when they formed the Berridale-Rocky Plains Landcare Group and were able to obtain funding to employ a project officer to coordinate a serrated tussock control program. With serrated tussock now much better controlled, land managers continue to ensure the weed does not once again reach unmanageable levels.

The problem

In 1997 it became clear to a group of farmers in the Snowy River Shire that serrated tussock was infesting their land and the surrounding area at an alarming and uncontrolled rate. Infestations occurred even though each land holder attempted to contain serrated tussock on their own land by the application of herbicides.

The problem for these farmers was compounded by the fact that there were other land holders in the area, many absentee, who were making no attempts at all to control the tussock. Wind blown seed infested from these uncontrolled areas continuously reinfested previously cleared areas.

The approach

In 1998, the Berridale-Rocky Plains Landcare Group formed to challenge the serrated tussock problem, among other weeds. The group formed a partnership with the Snowy River Shire Council and set five objectives:

- 1. A coordinated approach.** A project officer was engaged to coordinate the project. The Council provided the officer with office facilities, a vehicle at a competitive rate and worked closely with him without compromising his role as a Landcare Coordinator. The project officer facilitated communication between land

Key messages

- When dealing with widespread infestations of serrated tussock over many landholdings, it is important to implement a coordinated approach.
- Ensuring that land managers have both the skills and resources to participate in a control program is essential to success.
- Even after the objective of the program – control of serrated tussock – has been reached, the long-term success can only be assured with ongoing follow up.

holders, helped develop integrated plans for controlling serrated tussock depending on the specifics of the situation, vetted and supervised contractors, provided an educational and informational role, and networked with other groups such as the Serrated Tussock Working Party and Monaro Regional Weed Committee.

Maps produced detailing the locations of serrated tussock infestations provided a significant mechanism for directing effort and planning best approaches. The mapping exercise showed that of the 104,000 hectares originally thought to require attention, only 36,000 hectares should be targeted for control.

- 2. Involving all land managers.** At the outset, the project officer wrote to four hundred land holders telling them about the project and inviting them to become involved. Major landholding neighbours: National Parks and Wildlife Service, and the Rural Lands Protection Board, agreed to cooperate. The aim of the project was to encourage land holders to become involved without Council having to resort to legal action. Instead, land holders were offered a number of incentives, which increased their capacity and resources to deal with the weed problem.



Don Clinton

Landholders meeting to discuss project.

3. Increasing resources. The project provided direct cash incentives to land holders for cooperating in the program. The initial major cash injection centred on a three year Federal Government funded National Heritage Trust (NHT) grant, which was extended to four years. The grant largely paid for the project officer and specialist contractors. The application for the NHT grant defined the nature and scope of the activity, and the nature of the cooperation between the Landcare Group and Council.

A significant incentive to land holders was the offer by Council to provide herbicides at a 20% discount to project participants. A majority of land holders made use of the herbicide purchase offer.

In addition, land holders who chose to use contractors for some of the work associated with serrated tussock control had 40% of the contractor's costs paid for through project funds (\$5000 limit per land holder). Contractors carried out spraying operations as well as sowing competitive pasture through direct drilling method according to pre-established protocols. One hundred and three land holders took advantage of the contract work offer.

The project officer coordinated several programs where small land holders worked in groups to carry out weed control on each other's land. This had good social and educational benefits as well as pooling effort.

4. Raising knowledge levels. To begin with, the project area was defined by the erection of four large signs at key entry points to the Landcare area. The signs highlighted the areas were infested by serrated tussock and African lovegrass.

As well, the project team hosted a local seminar, titled 'Recovering the Monaro', where key speakers demonstrated a holistic approach to weed control, and emphasised the need for vegetative competition and management. Throughout the project's four-year NHT funded period, land holders and the community were frequently updated about the project through media releases and newsletters.

Land managers were then assisted in a variety of ways to develop integrated plans for the management of serrated tussock on their land.

5. Taking action. The coordinated approach resulted in many different approaches to controlling serrated tussock. The project officer particularly noted the following initiatives:

- Hobby farm owners were encouraged to carry out minimal grazing to increase competition from existing vegetation.
- Land owners received help with large-scale planting of improved pasture species by direct drilling.
- The use and benefits of reduced rates of flupropanate application on small serrated tussock plants was demonstrated.
- Small severely degraded sites that were infested with the tussock were treated by cutting mature seeding pasture with a forage harvester, transporting chopped material and spreading it, mixed with fertiliser, over the degraded site.
- Some paddocks were treated with clover and fertilizer after extensive spot spraying
- Pine trees were purchased and land holders were given help to plant them as buffer zones to serrated tussock seed spread.
- The Cooma Rural Lands Protection Board was given assistance with rabbit control works on properties as part of their revegetation program.

The result

According to Council, as a result of the project, about 350 land holders, representing 90% of the target area, now satisfactorily manage their weed problem. In general, there is greater management of weeds, and a greater awareness of the need for ground cover and, in particular, competitive species in the pasture. Direct drilling of competitive grasses is now widely used. Land holders and the wider Snowy River community accept that weed control is best achieved using a combination of different control methods. A positive outcome of the project is that considerable work was generated for local full and part-time contractors. These appropriately trained and experienced contractors remain available for follow up work.



Don Clinton

Example of spray control on serrated tussock carried out via this project.



Don Clinton

Example of successful pasture improvement to replace serrated tussock done via this project.

The future

The NHT funded period of the project concluded in 2002, however, the Snowy River Shire Council continues to inspect properties and map serrated tussock infestations in the Landcare area. Council Officers inform new land holders of their responsibilities regarding noxious weeds, and provide assistance with weed identification and control techniques. Where required, Council issues notices and fines under the various sections of the Noxious Weeds Act 1993. The area has suffered from severe drought since completion of the project. Unfortunately some pastures have been re-invaded by serrated tussock as a result.

Case Study 7

Managing serrated tussock in conservation native grasslands

Summary

ACT Parks, Conservation and Lands use spray “lances” to selectively target individual serrated tussock plants with herbicide minimising damage or spray drift to surrounding native species. Although painstaking, the approach has produced excellent results, successfully reducing serrated tussock infestations in conservation areas.

The problem

Serrated tussock is identified as a threatening process under the NSW Threatened Species Act. It can invade native grasslands, especially those with sparse ground cover. The weed can quickly outcompete native species, dramatically reducing the biodiversity of an area and forming a monoculture. Plants begin to produce high volumes of wind-dispersed seed two years after germinating, enabling a rapid rate of spread.

Serrated tussock control is now recognised as one of the highest weed control priorities in the ACT. ACT Parks, Conservation and Lands (ACT Parks) staff and land holders are encouraged and directed to treat new serrated tussock infestations as soon as they are discovered.

The approach

When controlling serrated tussock in lands managed for the conservation of native grassland, ACT Parks staff aim to minimise damage to off-target species and prevent serrated tussock seed set. The techniques they employ are:

Targeted application: ACT Parks staff spot spray glyphosate using a “lance” that gets the herbicide to the crown of each serrated tussock plant and allows thorough coverage of all leaves while minimising wind and operator “over-spraying”. They use glyphosate at 1% as the principle herbicide, increasing its efficacy during dry weather by adding a “non-ionic surfactant/mineral oil” to the glyphosate mix.

Follow up: Staff carry out regular and strategic monitoring of treated areas, spot spraying all newly detected plants. They believe it is critical for the weed’s long-term control to ensure that no serrated tussock be allowed to produce seed.

Key messages

- Widescale, careful and strategic spot spraying of serrated tussock using a “lance” does less damage to beneficial species promoting more competition and less serrated tussock re-invasion.
- Addition of the spray adjuvant “a non-ionic surfactant/mineral oil” to glyphosate mix has improved serrated tussock kill during dry times of the year.
- A key to long-term success is diligent and routine follow up.
- Serrated tussock management in conservation grasslands is expensive and needs ongoing community support to maintain the required resources.



Steve Taylor

Glyphosate spot spraying of serrated tussock using a lance to reduce off target damage.



Results of careful glyphosate spot spraying of serrated tussock.

Steve Taylor

ACT Parks staff do not recommend widespread use of flupropanate in conservation grasslands. Flupropanate can cause damage to beneficial grass species such as wallaby grass (*Austrodanthonia*) and *Microlaena*. The exception is in areas where the main native grass is Red-leg Grass, which is tolerant to low rates (1.5 L/ha) rates of flupropanate.

The result

ACT staff have succeeded in limiting the spread of existing serrated tussock infestations at Gungahlin and Jerrabomberra districts in the ACT. They have also managed to reduce the size of the main infestations while increasing the dominance of native grasses, for example Red-leg Grass, Hairy Panic and Tall Speargrass.

The future

The interaction of more frequent drought with overgrazing has increased the number of areas around the ACT that have sparse ground cover—prime territory for the invasion of serrated tussock. To ensure that serrated tussock infestations do not become even more critical, ACT Parks believes it is imperative that all new infestations, whether on public or private land, are quickly and continuously suppressed. ACT Parks, therefore, accepts that part of its role is to educate the wider community about serrated tussock and its control. Serrated tussock control requires the long-term financial commitment of the ACT government and the development of initiatives that may even include kangaroo culling to reduce grazing pressure on native pastures.



Steve Taylor

Before (2005) (left) and after (2007) (right) photos of spot spraying serrated tussock with Round-up Biactive at Jerrabomberra Grasslands Nature Reserve, ACT. The weed management here has shifted the area from serrated tussock dominant to tall speargrass dominant - so quite a success. Rigorous follow-up is the key to success.

Case Study 8

Emergency planning for new serrated tussock infestations

Summary

An emergency response plan – drawing on local, regional, state and national management resources – has been developed and applied following the discovery of a single serrated tussock plant on a Tasmanian roadside more than 100 km from the nearest known infestation. The plan identifies the stakeholders and the actions they need to undertake in order to manage the infestation site and prevent spread.

The problem

A passing motorist spotted a flowering serrated tussock plant growing on a highway embankment in Tasmania's north-west, more than 100 km from the nearest known infestation. The plant was growing in a major transport corridor, with multiple land managers at or near the site. There was therefore an urgent need to control the plant, survey surrounding areas, determine the source of the infestation, inform and bring together key stakeholders, and develop a long-term hygiene and monitoring strategy to prevent further infestation.

The approach

The Tasmanian Department of Primary Industries and Water (DPIW) was informed of the discovery by the regional Natural Resource Management (NRM) weed officer, who had himself been contacted by a local agricultural supply company which had been given a sample of the plant by the motorist. Confirmation of the plant's identity resulted in the implementation of an emergency response plan. The first step was to identify all the stakeholders responsible for managing the site and adjacent land. In this case it included the state agency responsible for highway management (and more importantly, the contractor they employed to manage the roadside reserve), the local government, the regional NRM organisation, and the owners of surrounding private property. An on-site meeting was organised for DPIW staff, weed managers from the NRM region and local government, and the contractor. The purpose was to inform managers of the exact location of the serrated tussock plant, undertake physical control of any other serrated tussock plants, and provide training in identification. This meeting took place within 72 hours of the original notification, and provided an excellent opportunity to discuss future site management and hygiene protocols

Key messages

- Investing in the training of land managers in serrated tussock identification can prevent new infestations and protect valuable industries.
- Developing early response plans with clearly defined roles is valuable in order to manage new infestations, especially where there are multiple land managers involved.
- Cooperation between different levels of government and land management significantly increases the chances of success.
- Communicating with all stakeholders is vital if new infestations are to be appropriately managed.
- Eradication sites must be monitored at least twice a year in order to detect new seedlings and prevent seeding.

with the contractor. In the following week adjacent land holders were informed of the discovery and provided with identification and management materials. They were also notified that formal property inspections would be undertaken by DPIW staff in the coming weeks.

At the time of the initial inspection, six seedlings were identified and removed. It was therefore concluded that the plant must have been present for at least one flowering season prior to detection. Adjacent properties (which included sheep and cattle grazing, and horse stables) were surveyed on foot, with the search radius extending for 1 km from the original infestation. The search was extended downwind from the infestation by an additional 500 m, and any recently cultivated areas within 1.5kms were also surveyed. No other serrated tussock plants were found.

All stakeholders were informed of the survey results. Monitoring has continued at six-monthly intervals. In the first six months a further 13 seedlings were removed. In the next (and most recent) six months, 32 seedlings were found. All of these have arisen within two metres of the parent plant.

The result

No serrated tussock plants have been found near the site and no known flowering has occurred since the original discovery. The contractor continues to apply a hygiene protocol whereby the embankment area is first inspected for flowering serrated tussock and is the last site mown prior to machinery clean down on-site. Local government, NRM and DPIW staff continue to monitor and remove seedlings. Surveying for serrated tussock has been included by local government as a condition of some kinds of development in the area to extend community awareness and detection capability.



Andrew Crane

The isolated Tasmanian serrated tussock site that's been treated and had regular follow-up to ensure no serrated tussock regrowth.

The future

The site will continue to be monitored on a six-monthly basis for at least the next five years. Land holders will be provided with regular updates, and significant changes in land-use (such as conversion to timber plantation) will require site surveys and the application of strict hygiene protocols.



The serrated tussock plant collected from the Tasmanian roadside site for identification and disposal. The large number of seeds emphasises the importance of early detection and follow-up monitoring of re-invasion.

Greg Stewart

Case Study 9

Serrated tussock control in native pasture and timber country

Summary

Twenty-five years of vigilant and careful spot spraying has restored native pastures once heavily infested with serrated tussock. Robert Friend's NSW property once again supports viable and productive native pasture for sheep production.

The problem

When Robert Friend purchased his 648 ha property in Trunkey Creek on the NSW Central Tablelands in 1983, he also bought himself a serrated tussock problem. Every cleared hectare of Robert's 648 ha property had varying densities of seeding tussock.

The property itself is a mixture of native pasture and timber, stocked with sheep. It is situated on difficult to access hilly country with soils that derive from shale and range from rocky ridges to alluvial flats. Average rainfall is around 700 mm per annum.

The approach

Robert has used only spot spraying to control serrated tussock, but he is systematic in the way he spot sprays, spending between 20 to 100 days a year on the control exercise. Using flupropanate at around 0.2% or a mixture of flupropanate and glyphosate (the addition of glyphosate enables him to control other nuisance weeds at the same time) he:

1. Selects an area of the property for control.
2. Begins the control effort by targeting serrated tussock plants on upper rockier slopes and gradually works downhill. In this way he controls areas that have sparser infestations first. He also concentrates on those areas where predominant winds blow.
3. Covers each serrated tussock plant with herbicide but is careful not to over-spray onto surrounding grasses, enabling these surviving grasses to cover areas laid bare by dead tussock plants.
4. Meticulously follows up by visiting areas already treated at least twice a year to spray out emerging serrated tussock plants.

Key messages

- Systematic and strategic spot spraying of serrated tussock is effective when the aim is to enable existing beneficial pasture species to compete.
- Carefully monitored rotational grazing can help to maintain pastures with little serrated tussock invasion.



Aaron Simmons

Robert Friend spot spraying serrated tussock on his property at Trunkey Creek, NSW. "The key is careful targeted application to individual serrated tussock plants and remember to "follow-up".

The result

It was five years before it was obvious to Robert that the serrated tussock infestation on his property had reduced. Now, twenty-five years later, he has 400 ha of healthy native Redgrass pasture, with half the remaining land either usable pasture or natural bush.

The future

About 120 ha of the property still contains serrated tussock infestations. Robert sprays out about 8000 L of mixed chemical in a year using only a knapsack – and he intends to keep on doing so till his property is entirely free of serrated tussock.

Case Study 10

Serrated tussock strategy pays off

Summary

A 20-year serrated tussock control program is one of the factors that has helped Murray and Barbara Stephenson double the carrying capacity on their property 'Brooklyn', at Binda, near Crookwell, NSW.

The problem

When Murray and Barbara Stephenson bought the farm 25 years ago serrated tussock was identified, but the extent of the problem was not realised until five years later, when it had spread rapidly across the 340-hectare property. It was only then that they realised it was such a prolific seeder, with new infestations rapidly occurring downwind from existing stands, or on land where soil had been disturbed.

The greatest impact of the serrated tussock infestation was on the carrying capacity of 'Brooklyn'. Where the weed was not controlled in the past, Murray estimated there was a large reduction in the stocking rate, as the weed competed with both introduced and native pastures. Today 'Brooklyn' carries 1700 Merino and first cross ewes, producing 1700 lambs a year.

The approach

Little information was available about control methods when serrated tussock was first recognised as a problem and the Stephensons' approach was largely based on trial and error. They originally wanted to achieve maximum impact to control serrated tussock, and so their first approach was to plough out the weed from the worst-affected areas and introduce improved pastures, including clover, cocksfoot and ryegrass, in the hope that these would out-compete serrated tussock. Unfortunately, ploughing and cultivation encouraged the weed to spread further and the pasture species could not compete.

Murray and Barbara soon learnt that it was necessary to treat the weeds with herbicide during the pasture-establishment phase.

Serrated tussock also infests native pasture on 'Brooklyn', and in these places Murray and Barbara have relied on herbicide.

Key messages

- Be vigilant – watch for new serrated tussock germinating and act quickly.
- Apply chemicals to serrated tussock plants only – if spray affects the surrounding pasture species, their vigour and competitiveness is reduced, thereby reducing the effectiveness of weed control.
- Chemical concentration can be quite low, and therefore cost-effective, if spot spraying is undertaken at the right time and applied correctly.

The Stephensons have undertaken two key phases of the control program.

- For the first 15 years, they undertook an intensive spot spraying and pasture-improvement program, requiring about two weeks of full-time labour each year. This largely eradicated the larger patches of serrated tussock and reduced the number of new seedlings.
- Over the past five years, Murray and Barbara have been able to scale down their control program. Murray now spends only two days a year spot-spraying any new seedlings, with a focus on those parts of the farm where the soil has been disturbed. Their control strategy relies on herbicide treatment, complemented with competitive pastures. Cultivation is now used only to establish improved pastures and not as a tool for serrated tussock control.

The preferred method of control for serrated tussock is the application of flupropanate, which in Murray and Barbara's experience has been superior to glyphosate.

Murray and Barbara have learnt over time that the key to success with herbicide is to allow pastures to gain a competitive advantage over the sprayed weed. They believe there are two critical tactics to achieve this:

- spray serrated tussock when pasture species (improved or native) are dormant
- spot-spray weeds to avoid chemical damage to surrounding pastures.

Murray uses a novel approach in his spray application for serrated tussock: a modified drench gun to apply a metered dose to each tussock plant. Because the spray is targeted to the base of the plant, it has minimal effect on the surrounding pasture cover, helping to reduce the area of bare ground on which serrated tussock seed could germinate.



Stephenson

Murray Stephenson of 'Brooklyn', Binda, says various techniques such as spot spraying have helped weed control on his property.

Ensuring pastures retain their vigour is also important. For the introduced pastures, fertiliser is applied at rates based on soil test results. This averages about 125 kilograms per hectare of single superphosphate per year. For the native pastures, about every five years Murray excludes stock in late spring to allow the pastures to set seed.

The result

The control program implemented on 'Brooklyn' has allowed grazing capacity to double over the past 20 years, thereby improving farm profitability.

Given that the carrying capacity has risen from 3.5 dry sheep equivalent per hectare (DSE/ha) 20 years ago to seven DSE/ha today, the return from each hectare of the farm has essentially doubled. Based on an estimated gross margin of \$40/DSE, Murray has, over the past 20 years, increased annual returns by about \$140/ha.

In addition, Murray says that the value of the farm has also increased, now that it is relatively free of serrated tussock.

The future

The Stephenson's plan is to continue their serrated tussock management strategy and are aiming to eradicate this weed from their property.

Case study from – Australian Wool Innovation's *Beyond the Bale Edition 28*



Stephenson

'Brooklyn', Binda where the Stephensons have concentrated their attack on weed management.

Section 6

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Regulatory control of serrated tussock in Australia

State	Regulatory status (October 2008)	Areas covered	Legal restrictions
ACT	<i>Pest Plants and Animals Act 2005</i>	All ACT	<i>Schedule 1</i> Category 3 - Plants must be contained. A pest plant management plan is required to control the spread of these plants. Category 4 - Prohibited pest plant: the propagation and supply of the pest plant is prohibited.
NSW	Class 3 (<i>Noxious Weeds Act 1993</i>) Class 4 (<i>Noxious Weeds Act 1993</i>)	33 local council areas** in NSW Remaining local control authorities in NSW	The plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed. The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed.
NT	Schedule Class A/C (<i>Weeds Management Act 2001</i>)	All NT	Schedule Class A – To be eradicated. Schedule Class C – Not to be introduced into the Territory.
QLD	Class 1 [<i>Land Protection (Pest and Stock Route Management) Act 2002</i>]	All Qld	Plants not commonly present in the state and, if introduced, would cause an adverse economic, environmental or social impact. Class 1 plants established in the state are subject to eradication. It is an offence to introduce, keep or sell Class 1 plants without a permit.
SA	Class 1 (<i>Natural Resources Management Act 2004</i>)	All SA	Plant must be destroyed throughout the State (trade and movement usually restricted throughout the State). Notifiable throughout the State.
TAS	D – Declared weed (<i>Weed Management Act 1999</i>)	All Tas	Details on actual restrictions or measures for each declared weed are contained in the weed management plan for that weed. Must not import or allow to be imported, must not sell or distribute; must not propagate, harvest or store; and may be required to reduce, eradicate or restrict the weed.
VIC	P – Regionally prohibited weed (<i>Catchment and Land Protection Act 1999</i>) C – Regionally controlled weed (<i>Catchment and Land Protection Act 1999</i>)	East Gippsland, Glenelg Hopkins, Goulburn Broken, Wimmera, North East, North Central, Mallee catchments. Port Phillip & Western Port, Corangamite, West Gippsland catchments	Regionally prohibited weeds are not widely distributed throughout the region, are capable of spreading further and it is reasonable to expect that they can be eradicated from the region. Regionally controlled weeds occur in the region, are capable of spreading further and continuing control measures are required to prevent their spread.
WA	Prohibited (<i>Plant Diseases Act 1974</i>) P1 (<i>Agricultural and Related Resources Protection Act 1976</i>) P2 (<i>Agricultural and Related Resources Protection Act 1976</i>)	All WA	Prohibited – Plant species on the Permitted and Prohibited list not permitted entry into WA. P1 – Prohibits movement of declared plants and/or their seeds through the prevention of trade, sale or movement of plants into the state or that area of the state. P2 – Eradicate infestation to destroy and prevent propagation each year until no plants remain. The infested area must be managed in such a way that prevents the spread of seed or plant parts on or in livestock, fodder, grain, vehicles and/or machinery.

NSW Local Councils where serrated tussock is declared **Class 3: Albury, Balranald, Bland, Carrathool, Central Murray County Council, Coolamon, Cootamundra, Corowa, Glen Innes Severn, Greater Hume, Griffith, Gundagai, Gwydir, Hay, Inverell, Jerilderie, Junee, Leeton, Liverpool Plains, Lockhart, Murrumbidgee, Narrandera, New England Tablelands County Council, Tamworth Regional, Temora, Tenterfield, Tumbarumba, Tumut, Upper Hunter County Council, Urana, Wagga Wagga, Wakool, Wentworth.

Land holder training and community assistance programs

Depending on your need, there are a variety of specific training courses and community based groups that are available throughout Australia. This may be a structured course targeted at a specific area such as grazing management, or a community based group that has a focus of working together on a range of community issues, such as Landcare.

A number of grazing and pasture management training courses are available throughout the country. Private organisations, TAFE colleges, distance education organisations, agricultural colleges, Meat and Livestock Australia (MLA) and state government agencies run training programs that focus on pasture management, such as the Prograze® course. Further information on Prograze® can be obtained from: www.dpi.nsw.gov.au/agriculture/profarm

Points of contact that may have local information such as Landcare groups, extension programs, grazing management or herbicide training courses, possible assistance programs or funding include:

- Landcare coordinators
- local government weeds officer
- Catchment Management Authority (CMA) or Regional Natural Resource Management body
- noxious weeds authorities
- agronomists
- State government weeds officer
- community weed groups, for example, Victorian Serrated Tussock Working Party.

Contacts

Region	Telephone number	Website
Australian Capital Territory		
Parks, Conservation and Lands	13 22 81	www.tams.act.gov.au/live/environment
A.C.T Landcare	For current contact details visit website	www.actlandcare.org
New South Wales		
Department of Primary Industries	(02) 6391 3100	www.dpi.nsw.gov.au
Department of Local Government	For current contact details visit website	www.dlg.nsw.gov.au
Catchment Management Authority (CMA)	For current contact details visit website	www.cma.nsw.gov.au
NSW Landcare	For current contact details visit website	www.landcarensw.org
Queensland		
Biosecurity Queensland, Department of Primary Industries and Fisheries (DPI&F)	13 25 23	www.dpi.qld.gov.au
Local Government	For current contact details visit website	www.localgovernment.qld.gov.au
Regional Natural Resource Management	07 3222 2758	www.regionalnrm.qld.gov.au
South Australia		
Department of Water, Land and Biodiversity Conservation (DWLBC)	(08) 8303 9620	www.dwlbc.sa.gov.au
Local Government Association of South Australia	For current contact details visit website	www.lga.sa.gov.au
Regional NRM Boards	For current contact details visit website	www.nrm.sa.gov.au
Tasmania		
Department of Primary Industries and Water (DPIW)	1 300 368 550	www.dpiw.tas.gov.au
Local Government Association of Tasmania	For current contact details visit website	www.lgat.tas.gov.au
Natural Resource Management in Tasmania	For current contact details visit website	www.nrmtas.org
Tasmanian Landcare Association	For current contact details visit website	www.taslandcare.org.au
Victoria		
Department of Primary Industries	13 6186	www.dpi.vic.gov.au
Department of Sustainability and Environment	13 6186	www.dse.vic.gov.au
Victorian serrated tussock working party	03 5226 4607	www.serratedtussock.com
Local Government Victoria	For current contact details visit website	www.localgovernment.vic.gov.au
Victorian Landcare Gateway	For current contact details visit website	www.landcarevic.net.au
National		
National serrated tussock Coordinator	For current contact details visit website	www.weeds.org.au/WoNS/serratedtussock/
Weeds Australia	For current contact details visit website	www.weeds.org.au
Weeds in Australia	For current contact details visit website	www.weeds.gov.au
Department of Agriculture Fisheries and Forestry (DAFF)	(02) 6272 3933	www.daff.gov.au
Landcare Australia - National Landcare Directory	1800 151 105	www.landcareonline.com
Natural Resource Management regions	1800 552 008	www.nrm.gov.au/nrm

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Glossary and abbreviations

ad hoc	improvised and often with little or no preparation
adult plant	mature serrated tussock plant greater than 10 cm in height
annual	living only one growing season
APVMA	Australian Pesticides and Veterinary Medicines Authority
arable	land capable of being ploughed
awn	a fine bristle-like appendage that is attached to the seed
biomass	the total amount of living material in a given habitat or population
broadacre	term used to describe land suitable for practicing large-scale agricultural operations
C₃ grass	these grasses are usually adapted to cool temperate zones and generally have an active period of growth in the winter months; however some C ₃ grow yearlong; a grass that utilises the C ₃ photosynthetic pathway
C₄ grass	these grasses are usually adapted to warmer sub-tropical or tropical zones and have an active period of growth in the summer months; a grass that utilises the C ₄ photosynthetic pathway
chipping	physical removal of individual plant with either hoe or mattock; also referred to as hoeing or manual removal
CLIMATE	a modelling system that uses the climate of where current infestation levels of a weed in Australia to map the potential distribution of weeds
CMA	Catchment Management Authority
corona	a crown; in grasses, a ring of hairs at the tip of the seed between the awn and the seed
cultivation	ploughing to prepare the land to sow crops or pasture
DAFF	Department of Agriculture Fisheries and Forestry
digestibility	capacity of a food to be digested
dormant	a period where no growth occurs
DPI	Department of Primary Industries (New South Wales, Victoria)
DPIW	Department of Primary Industries and Water (Tasmania)
DSE	dry sheep equivalent a standard unit used to compare the feed requirements of different classes of stock and is frequently used to assess the carrying capacity and potential productivity of an area of grazing land. 1 dse is the amount of feed required by a two year old, 45 kg Merino sheep (wether or non-lactating, non-pregnant ewe) to maintain its weight
exotic	a plant introduced from another country
germinability	the ability of a seed to germinate
glume	of a grass, one or two sub-opposite empty bracts subtending internal flower parts in a spikelet

grazing management	the total process of ensuring pasture persistence and ground cover, maintaining soil nutrition for growth and organising livestock to make the best use of the pastures grown. It is about managing the frequency (how often the stock are removed) and intensity (how hard and how many) livestock graze pasture (MLA 2008)
ground cover	area of ground covered by actively growing plants or dead material
ha	hectare
habitat	the area or natural environment in which an organism or population normally lives. A habitat is made up of physical factors such as soil, moisture, range of temperature, and availability of light as well as biotic factors such as the availability of food and the presence of predators
IWM	Integrated Weed Management term used to describe a combination of control methods used for the long term control of a weed(s)
ligule	a membranous or hairy outgrowth on the inside surface of a leaf, at the junction of sheath and blade, especially in grasses and some sedges
MJ/kg DM	megajoules (1 million joules) per kilogram of dry matter . The unit given to describe the metabolisable energy (ME) content of a feed source. For example, a fibrous feed such as poor quality hay may have an ME value around 6.5 MJ/kg DM, whereas wheat, being low in fibre and high in starch, has an ME of approximately 13 MJ/kg DM
mother-lode	a hard to manage area or high seed source of serrated tussock that spreads to neighbouring areas
native grassland	have high biodiversity values and are a remaining remnant of previous widely distributed ecosystems. They possess a diversity of grasses, forbs and other species, including rare and endangered flora and fauna that requires active management and protection. Conservation native grasslands are non-grazed and non-arable
native pasture	grazed pastures used for agricultural production that consist mostly of a mix of native grasses and forbs. Species may include kangaroo grass, weeping grass, spear grass, wallaby grass or red grass. Pasture may or may not include introduced legume species, for example, subterranean clover
naturalised	an exotic species that, once introduced into an area, has the capacity to adapt to the new environment, survive in competition with the native floral and faunal populations, reproduce itself and establish itself as a persistent part of the plant community
non-arable	land that is not suitable for cultivation or for the production of crops—for reasons such as the land is too steep, rocky or timbered; may contain rare or valuable species; or have shallow or sodic soils
panicle	a flower head that is loosely branched in large clusters, like serrated tussock
pasture—good condition	a pasture used for agricultural production that has a high proportion of desirable pasture grass (introduced or native) and legume species, little bare ground and a low amount of weeds. If serrated tussock was removed from this pasture, the remaining desirable vegetation would be actively growing and provide enough ground cover to hinder the establishment of serrated tussock seedlings

pasture—poor or degraded condition	a pasture used for agricultural production that has a low proportion of desirable pasture species, and a large amount of bare ground and weeds. The existing ground cover and growth of the pasture would not provide enough competition to prevent serrated tussock seedlings from establishing. Pastures of this kind will require re-establishment to be competitive.
perennial	having a life cycle that lasts more than two years
peri-urban	low density housing on the periphery of urban areas, still retaining small areas of rural land—small acreage blocks generally 1–5 acres in size
PPMP	Property pest management plan
prevention strategies	implementation a number of techniques that will reduce the probability of serrated tussock seed spreading further
rotational grazing	practice of dividing up pasture into a number of smaller sized paddocks so that stock can be allowed to graze the pasture quickly, then removed to allow pasture a period of rest
seed bank	seeds that are present in, or on, the soil
seedling	a young serrated tussock plant less than 10 cm in height
senescence	the organic process of growing older and showing the effects of increasing age
set stocking	grazing systems in which stock remain in one field or paddock for a long period.
TAFE	Technical and Further Education
tiller	of a grass, a branch developed from a bud at the base of a stem
tussock	large clump or tuft as formed by some perennial grasses and sedges
vendor declaration	a declaration that states that all efforts have been made to ensure that the product, stock or vehicle is free of weed seed
WoNS	Weed of National Significance. Twenty weeds were formally identified

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