Economic options for serrated tussock (*Nassella trichotoma*) management on different classes of grazing land in the Geelong region of Victoria

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Summary

Information of the nature of infestations of serrated tussock in the Geelong region of Victoria was collected through a questionnaire survey of members of LandCare groups with an interest in serrated tussock control. Seventy six responses were received from 400 questionnaires distributed. Forty six responses were from properties with infestations, 30 from clean properties.

Published information on agricultural production, serrated tussock growth and impact and treatment options were used to assess the economic impact of infestations and the benefits of control programs. Control of infestations on land with higher potential carrying capacity returned a positive benefit from investment to control dense infestations or prevent scattered infestations from becoming dense. Programs on land with low carrying capacity were only economic where control provided protection from further spread. Analysis indicated that control to prevent spread was economic if infestations on such land were likely to increase in area by more than 140 per cent over a 20 year period.

It is concluded that control of all current infestations on productive land and all small infestations on low production land should be treated on the basis of direct benefit and to prevent losses from further spread. Subsidies for the treatment of large infestations on low production land is likely to be required. The economic justification for this is based on the prevention of spread. Since the control program would be expensive, it is suggested that the potential extent of serrated tussock and the rate of spread should be assessed more rigorously.

Introduction

Serrated tussock (*Nassella trichotoma* (Nees) Hack.) is a perennial tussock forming grass which can invade and persist as dense infestations on grazing land. Plants are rough and fibrous so are unpalatable and have low nutritional value. Preferential grazing of more palatable components of pastures contributes to serrated tussock becoming dominant, with the consequent reduction in carrying capacity of the infested area. Auld and Coote (1981) assessed that without control, dominance by serrated tussock could occur in 15 years from initial invasion. While light infestations cause insignificant losses (Auld, Vere and Coote 1982, Denne 1988) the carrying capacity of pastures dominated by serrated tussock can be as low as 0.5 DSE ha^{-1}, in country that could carry up to 10 DSE ha^{-1} (Campbell 1974). Vere and Campbell (1977) found that infested properties carried about only one third the normal stock numbers for the area in which they are located. Pastures most susceptible to invasion tend to have an inherently low productivity due either to climatic and soil conditions, poor management, or a combination of both. Campbell (1977) found the most susceptible pastures in the southern tablelands of New South Wales had a carrying capacity of around 2 DSE ha^{-1}, and Denne (1988) reported a figure of 3 DSE ha^{-1} for pastures in areas of New Zealand where serrated tussock was prevalent. Thus, while carrying capacity could presumably be reduced to 0.5 DSE ha^{-1} as above, losses or benefits from control are relatively small in absolute terms for such pastures. This limits profitability of control programs. Drought or overgrazing by stock or rabbits increase the susceptibility of pastures to invasion (Vere, Campbell and Scarsbrick 1981, Vere and Campbell 1977). On the other hand, pasture improvement greatly reduces the risk of invasion by serrated tussock (Vere, Campbell and Scarsbrick 1981) or re-establishment following control (Campbell 1974). Most seedlings that establish in a vigorous improved pasture are killed by competition in their first or second spring or summer (Campbell 1963).

Economic assessments of the impact of serrated tussock infestations and the benefit of control programs have been undertaken in Australia (Vere and Campbell 1977, Vere, Sinden and Campbell 1980, Vere and Campbell 1984, Vere, Auld and Campbell 1993) and New Zealand (Denne 1988). These showed that overall, control programs returned a positive net benefit through the increased production from infested areas and the prevention of further spread. Vere and Campbell (1984) noted, however, that treatments became uneconomic in low fertility/low rainfall situations because of problems in establishing and maintaining a competitive pasture. Denne (1988) concluded that the high cost of frequent grubbing of large, lightly infested areas to eradicate serrated tussock was inappropriate for economic reasons.

These assessments highlight a number of factors that must be taken into account in a control strategy. These include selecting methods that are efficient and effective for particular situations, and determining the need for and level of public assistance, where private investment by landholders is not profitable. Consequently, a landholder questionnaire survey was undertaken of members of LandCare groups in the Geelong region, to identify which of the factors have implications for the development and implementation of a serrated tussock management strategy for this area. A complete evaluation of current infestations in relation to these factors should be undertaken as part of the strategy development.

Nature of the study area

Serrated tussock infestations were first recorded in Victoria in 1954, just north of Melbourne (Parsons 1973). Since then it has become well established in the Geelong region between Melbourne, Bacchus Marsh and Torquay. Currently, however, there are no close approximations of the extent and severity of established infestations or details of the situations infested. Much of this area is a flat basalt plain with rocky outcrops, dissected by rivers and streams with steep banks. The main river valleys extend back into a higher plain around the perimeter of the lower plain cutting into underlying marine sediments. The coastal area between Geelong and Torquay is light sandy country. The whole area has an average annual rainfall of between 500–700 mm with local rainshadow or higher rainfall areas. The higher plains receive above 700 mm per year. The area is used for grazing, cereal cropping and irrigated horticultural crops around Werribbee and Bacchus Marsh. Near Melbourne agricultural land is being converted to urban and industrial use. Many of the infestations are in this non-agricultural zone where herbicide application is subject to restrictions and pasture establishment not consistent with longer term land use objectives.

The landholder survey

In 1990, four hundred questionnaire surveys were sent out to members of LandCare groups in the Geelong region whose members had a particular concern with serrated tussock. Individuals were not asked to identify themselves in an attempt to overcome resistance to responding. Seventy six completed questionnaires were returned, 46 from properties with infestations and 30 from clean properties.

These are assumed to be representative of the general nature and extent of infestations.

The questionnaire asked for information about the size of properties and the main farming enterprises. More specific information was asked about the types of pasture on the property (irrigated, improved, volunteer, native and weedy – descriptive guidelines were given), features of the land (slope, soils and seasonal moisture status), and the area (ha) on which these pastures were growing. Areas (ha) of any dense, medium or scattered infestations were given separately for any of the combinations of pasture type and land features described for the property. Not all pastures/land features reported were necessarily infested by serrated tussock which was indicated by nil entry for infestation details. In addition, the first date that infestations were noted and possible source of seed and details of control programs were requested.

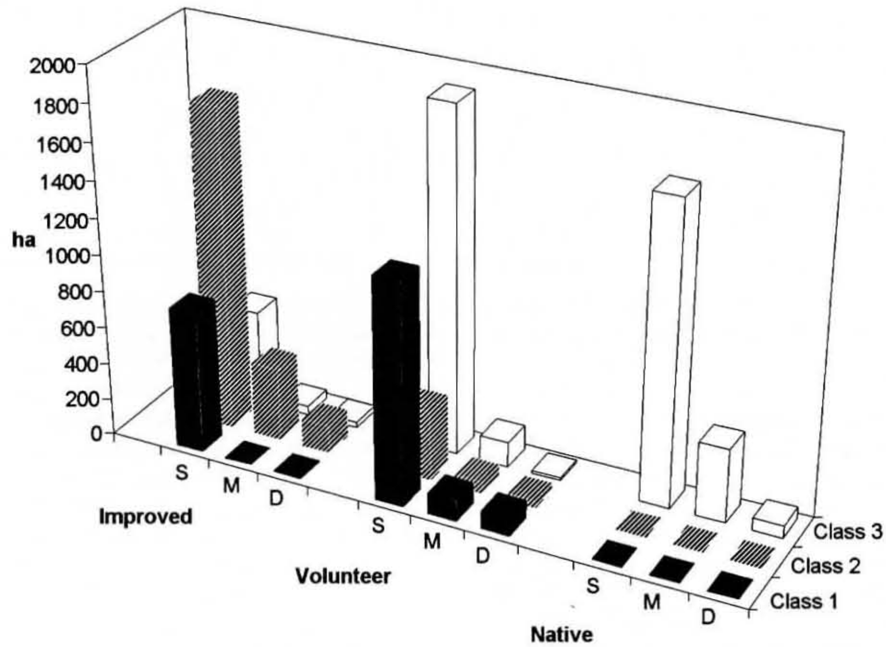

Figure 2. The area (ha) of scattered, medium and dense infestations of serrated tussock, in improved, volunteer and native pastures, on each class of land. S = scatterd, M = medium, D = dense.

Analysis of serrated tussock infestations

From the details of topography, soils and moisture, and with reference to the estimated carrying capacity, situations were classified as productive, arable land (Class 1), moderately productive, arable land (Class 2) and low production, non-arable land (Class 3). These correspond approximately to:

i. the areas with better soils and good rainfall on the plains, river flats and coast,

ii. the areas where soils or rainfall are reasonable and

iii. the steep valley sides, stoney areas of the plains or the poorer coastal soils that are recognizable at a general level in the Geelong region.

Pastures were generally classed as improved, volunteer or native. As shown in Figure 1 improved pastures were predominantly on Class 1 and 2 land, while Class 3 land had volunteer or native pastures. Responses suggested that most of the pastures on areas of Class 1 and 2 land had been improved.

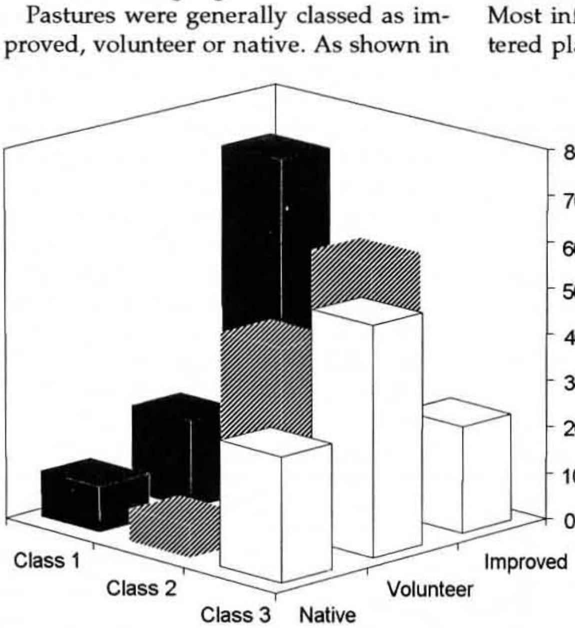

Figure 1. Percentage of pasture types on each class of land.

Estimations of carrying capacity were approximately 10 DSE ha^{-1} for improved pastures on Class 1 land, 6 DSE ha^{-1} for volunteer pastures on good land and all pastures on Class 2 land and 3 DSE ha^{-1} for all pastures on Class 3 land. These estimates corresponded with Department of Agriculture estimates for the region (Muir personal communication).

The area of infestations of each density on each class of land is shown in Figure 2. Most infestations were reported as scattered plants, with similar total areas occurring in each pasture type. The classification of such a high proportion of infestations as scattered is not consistent with reports of serrated tussock infestations in New South Wales and New Zealand, or with personal observations of infestations in the Geelong region. Some control work was reported from 76 per cent of infested properties. However, work was not categorized by pasture types or land classes. The control work reported has probably reduced the density of infestations on properties, but would not have affected the range of land features or pasture types from which the infestations were reported. The information provided has been accepted as indicative of the distribution and extent of infestations, but the analysis allows for infestations to be medium or dense. The actual densities of infestations in the field should be reassessed to confirm this judgement.

The proportion of the total area of each pasture type on each class of land was calculated to indicate the relative susceptibility/resistance to infestation by serrated tussock (Table 1). The analysis is based on information from infested properties, so that apparent resistance or susceptibility of pasture type-land class combinations is derived from situations where serrated tussock is present.

The general trends shown are an increase in the incidence of serrated tussock on Class 3 land, and in volunteer and native pastures. There are virtually no native pastures recorded from Class 1 and 2 land so the low incidence of infestations may reflect limited opportunity as much as high resistance to invasion. The apparent high susceptibility of volunteer pastures on Class 1 land is possibly associated with the failure to sow pastures after cropping so any tussock seedlings that were able to establish with or after the crop, have been able to persist.

Few respondents to the survey attempted to estimate the impact of serrated tussock on carrying capacity. The trend was for impact to increase as density increased. However, the assessments were not consistent in regard to the degree of impact. For the economic analysis, therefore, we have used the estimations of Vere, Campbell and Scarsbrick (1981) to generate carrying capacities for pasture types for each land class, with zero,

Table 1. The percentage of the area (ha) of each pasture type-land class infested by serrated tussock.

Land type	Class 1			Class 2			Class 3		
Infestation	Dense	Medium	Scattered	Dense	Medium	Scattered	Dense	Medium	Scattered
Improved pasture	0.2	0.1	17.5	2.3	5.8	25.6	3.7	6.2	63.0
Volunteer pasture	7.0	7.0	84.0	5.2	8.6	49.0	0.5	5.0	70.0
Native pasture	0	4.8	0	0	0	100	2.8	17.0	69.0

scattered, medium or dense infestations of serrated tussock. These are given in Table 2.

Proposed programs for the management of serrated tussock infestations

For the economic analysis, treatment options were developed. They are based on published procedures (Vere, Campbell and Scarsbrick 1981, Campbell, 1982). Low intensity treatments to maintain infestations at a low density were considered in response to Denne's (1988) conclusion, as presented in the introduction, that frequent grubbing of large, scattered infestations was not economic.

The cost-benefit of options was analysed as described below. The five options presented have been chosen as examples of treatments that would be appropriate in the situations described for the Geelong region. They are not the only options that could be appropriate. However, they probably represent the minimum cost to treat the infestations described, with control in practise likely to be more, rather than less expensive. Also, additional costs such as fencing or rabbit control that could be needed in particular cases, have not been included.

Option 1. Extensive infestations in unimproved pastures on Class 1, 2 and 3 land

- Apply 2l ha^{-1} Flupropanate® by boom or from air to control established plants.
- Spray after autumn break to prepare a seed bed, oversow improved pasture species, withhold grazing for one year.
- Top dress with fertilizer annually, to maintain pasture.
- One additional application of 2l ha^{-1} Flupropanate® to control surviving and seedling tussocks.

Option 2. Extensive infestations in unimproved pastures on Class 1 land

(This option is not applicable on non arable land where cultivation and cropping is not possible)

- Crop the area for two years. Cultivation will control established plants. Cropping is assumed to cover the cost of cultivation.
- Sow improved pasture species, withhold grazing for one year.
- Top dress with fertilizer annually to maintain pasture.
- One additional application of 2l ha^{-1} Flupropanate® to control surviving and seedling tussocks.

Option 3. Extensive, medium infestations in improved pastures on Class 1, 2 and 3 land

- Apply 2l ha^{-1} Flupropanate® by boom or from air to control established plants.
- Top dress annually to maintain pastures.
- One additional application of 2l ha^{-1} Flupropanate® to control surviving and seedling tussocks.

Option 4. Extensive infestations in unimproved pastures on Class 1, 2 and 3 land suppression only

- Apply 2l ha^{-1} Flupropanate® by boom or from air every five years to control established plants.
- Top dress with fertilizer annually to maintain pasture.

Option 5. Small infestations being treated to prevent establishment or spread

- Apply 2l ha^{-1} Flupropanate® by boom to control established plants.
- Spot spray or hand chip every three years thereafter.

Economic evaluation of the management options

A benefit-cost analysis was used, with net present values calculated over a twenty year period using a discount rate of 8% and a gross margin value for sheep of $20.00 per DSE. A number of assumptions have been made based on the knowledge available on serrated tussock and grazing enterprises.

i. Benefits will result either from an increase in carrying capacity resulting from the removal of serrated tussock and improvement of pastures, or from the improvement of pastures and the prevention of reductions in future carrying capacity that would result if the serrated tussock infestations were allowed to increase in density and extent.

ii. Carrying capacity following control of serrated tussock and pasture improvement will be nil in the first year, then increase to the maximum level over the next three years.

iii. Benefits from treatments to prevent scattered infestations from becoming dense are based on the assumption that the reduction in carrying capacity will occur over a ten year period. Overall benefits of prevention are therefore slightly less than benefits from the control of established dense infestations since the loss of productivity is gradual, whereas restoration to full productivity is achieved over three years.

iv. Pasture improvement on non-arable land is not always successful and up to one in four pastures have to be resown (Vere and Campbell 1977). A risk factor of 10, 15 and 25% has therefore been built into the cost of pasture establishment by oversowing on Classes 1, 2 and 3 land.

v. Labour costs of $20.00 ha^{-1} have been included in spot spraying and hand chipping treatments. The net present values estimation assumes that it takes two hours to treat one hectare by these methods. Landholders often choose not to include the cost of their own labour in budgets. However, we considered it important to allow for the "opportunity cost" of time spent on weed control since it is likely to divert the farmer from other productive activities on the property.

The net economic benefit of each of the management options is presented in Table 3. The calculations have been based on the control of initially dense infestations, except for Option 3 which is the control of infestations in previously improved pasture, so the assumption has been made that competition would be sufficient to prevent serrated tussock from becoming dense. The figures for carrying capacity show the level prior to and following treatment.

The analysis shows that the control of dense infestations on Class 1 and 2 land

Table 2. Estimated carrying capacity (DSE) of pastures for each land class.

		Dense	Medium	Scattered	Clean
Improved pastures	Class 1 land	2	6	10	10
	Class 2 land	2	4	6	6
	Class 3 land	1	2	3	3
Volunteer and native pastures	Class 1 land	2	4	6	6
	Class 2 land	2	3	4	4
	Class 3 land	1	1	2	2

provides a positive return on private investment. Pasture improvement or the treatment of initially scattered infestations to prevent future losses from dense serrated tussock infestations would be similarly worthwhile. The treatment of medium density infestations on Class 2 land (Option 3) returned a small negative net present values (- \$5 ha^{-1}), based on the likely increase in carrying capacity from 4 to 6 DSE ha^{-1}. If the infestation were to become dense, however, the benefit from preventing a future further loss in carrying capacity would make this option worthwhile. However, only 2.3 per cent of improved pastures on Class 2 land were reported to have dense infestations of serrated tussock. If this is an indication that improved pastures on this class of land are generally sufficiently competitive to maintain infestations at medium or scattered densities, there would be no additional future benefit. This needs to be evaluated more thoroughly in the field, if strict economic assessments are to be used for decision making.

All treatment options on Class 3 land returned negative net present values. This shows that protection of land with low inherent carrying capacity is a high priority, since once infested, restoration is not economic. However, control of serrated tussock and other weeds is undertaken as much for the prevention of further spread as for the reduction of current impact. For this reason an assessment of the economic benefit of options for Class 3 land was undertaken which included future benefits derived from preventing spread.

Table 3. The net present value (NPV) of management options for each class of land based on increases in carrying capacity from the initial to subsequent level indicated.

Option		Class 1 land	Class 2 land	Class 3 land
1	Cost	\$489	\$489	\$489
	NPV	\$642	\$183	- \$123
	Carrying capacity increase DSE ha^{-1}	from 2 to 10	from 2 to 6	from 1 to 3
2	Cost	\$300		
	NPV	\$716	na	na
	Carrying capacity increase DSE ha^{-1}	from 2 to 10		
3	Cost	\$344	\$344	\$344
	NPV	\$333	- \$5	- \$166
	Carrying capacity increase DSE ha^{-1}	from 6 to 10	from 4 to 6	from 1 to 2
4	Cost	\$425	\$425	\$425
	NPV	\$645	\$324	- \$50
	Carrying capacity increase DSE ha^{-1}	maintain at 6	maintain at 4	maintain at 2
5	Cost	\$225	\$225	\$225
	NPV spot spraying	\$452	\$114	- \$47
	NPV chipping	\$476	\$138	- \$23
	Potential loss prevented DSE ha^{-1}	from 6 to 2	from 4 to 2	from 2 to 1

Estimate of benefit when prevention of spread is included

The primary economic justification for an action is the return of a positive benefit and not the size of that benefit unless alternative investments are being compared. Therefore, it was decided to calculate the area (ha) of pasture that would have to be protected so that the program would return an overall positive net present values. On this basis the net present values of Option 1 on Class 3 land, of an initially dense infestation, was recalculated over a twenty year period. Benefits were calculated for increases in size of 50, 100, 150 and 200 per cent in area of the original infestation over this period. The calculations allow for the build up of density on the area becoming infested from scattered to medium after 10 years and medium to dense after 15 years. Carrying capacity was assumed to be unaffected for the first 10 years, reduced from 3 to 2 DSE ha^{-1} in years 11 to 15 and from 2 to 1 DSE ha^{-1} for the last five years.

The analysis showed that if a dense infestation on Class 3 land that was not treated increased in area by more than 140 per cent, i.e. 1 ha increased to 2.4 ha, at the rate described, the net present values of the treatment would become positive (Figure 3). Similar benefits through the prevention of spread would apply to the other options.

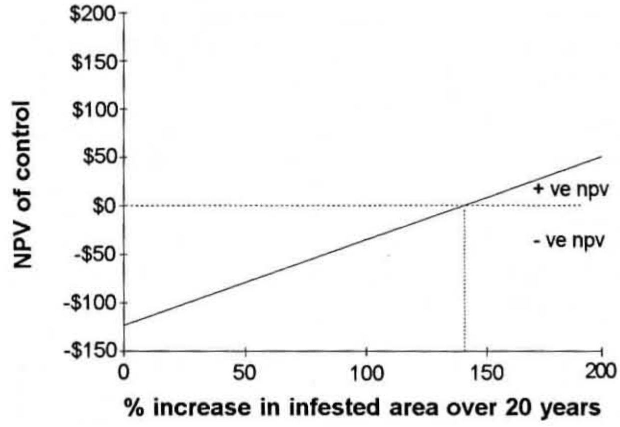

Figure 3. The net present values (NPV) of treatment of dense infestations of serrated tussock on Class 3 land for increases in area (ha) of infestations of 50, 100, 150 and 200 per cent over twenty years.

Because of the significance of spread to a positive return on investment in control of infestations on Class 3 land, the probability that scattered infestations will become dense over an area 140 per cent greater than they currently occupy within 20 years, needs to be evaluated. Serrated tussock certainly has spread and established on properties within the Geelong region. However, from the returns received, infestations have not established on all properties within the affected area. Similarly, infestations have not established on all parts of affected properties. Analysis of the pasture type/land classes infested were consistent with observations, presented in the introduction, that low production pastures are more susceptible to invasion and that competitive pastures can suppress the establishment of seedlings. Pasture improvement may therefore provide one barrier to spread. If barriers do occur, they need to be identified and taken into consideration in the economic evaluation of strategic options that include containment as one of the economic benefits.

Discussion and conclusions

This analysis applied information about the development, impact and control of serrated tussock to infestations, as they were described, in the Geelong region of Victoria. It is accepted that the information comes from a relatively small number of properties, however, it provides a basis for an assessment of the economics of control options. The assessment indicates the economic outcomes of strategies based on the descriptions of infestations and the situations in which they occur. The analysis does, therefore, give a focus to information that should be collected in future field studies, to challenge or verify the conclusions that have been drawn.

The region has a diversity of physiographic features which influence land use, particularly the types of pastures that are present and their carrying capacity. These were categorized into three classes of land and three types of pasture (improved, volunteer and native). Infestations of serrated tussock were reported from almost every combination of land class and pasture type. The area of native pasture remaining was relatively small and mainly on the poorer Class 3 land. Most of the improved pastures were on the better Class 1 land with a corresponding larger proportion of volunteer pasture on the Class 2 and 3 land. A high proportion of the area of all pastures on the Class 3 land and volunteer pasture on the Class 1 and 2 land was infested by serrated tussock. This is consistent with the observation that serrated tussock is more invasive where competition from pasture species is low. The infestations in improved pastures possibly results from poor management in individual cases.

The economic analysis indicated that treatment of infestations on Class 1 and 2 land was profitable and landholders should be encouraged to implement control for their own benefit and to reduce the risk of further spread. Some advice on pasture improvement and management may be necessary since infestations were reported from some areas considered by the farmer to have improved pastures. Because the cost of implementing control is high, provision of repayable financial assistance may have to be considered.

Treatment of infestations on Class 3 land is not profitable unless infestations increase or infest new situations equivalent to 140 per cent or more of their area, over a twenty year period. Because Class 3 land appears most susceptible to invasion, protection of such areas is important since restoration following infestation is not profitable. The analysis confirmed Denne's (1988) analysis that greater net benefits are obtained from less frequent control operations. This means a policy of containment rather than eradication, of extensive infestations on Class 3 land should be considered in control strategies. The decision on the level of control to aim for and who should finance programs depends on infestations actually spreading at the rate indicated. Again, there is no actual measurement available. Decisions will probably be based largely on the cost of implementing programs and available budgets. Treatment of small infestations on or near properties with large areas of Class 3 land should be given high priority. Cost should be borne by the landholders at risk and group programs currently underway are a good way of facilitating this. For larger areas, particularly on non agricultural land, government is likely to be asked to fund control programs since treatment will not be profitable for individual landholders. Government is increasingly asking that the technical feasibility of proposed programs be demonstrated, along with assessments of social and economic benefits and implications of financial constraints. In a regional example of serrated tussock control in New South Wales, Auld, Vere and Coote (1982) concluded that financial and physical constraints outweighed the economic case for an immediate eradication option over containment options.

Ultimately, an optimal course of action will be a matching of technical approaches with economic outcomes. This analysis is an attempt to indicate how both of these relate to the extent and severity of infestations, the nature of individual situations and the distribution of different types of situations across the broader landscape. The results are not presented as the final analysis of serrated tussock in the Geelong region, but are intended to show what conclusions can be drawn from existing information. This indicates information that should be generated where assumptions have had to be made and to verify the conclusions.

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