# final report

Project code: B.WEE.0137

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Date published: November 2008

ISBN: 9781741919899

**PUBLISHED BY**

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## Scoping a management program for fireweed on the South Coast of NSW

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication

# Abstract

A scoping study of the impact and nature of the fireweed (*Senecio madagascariensis*) problem on the South Coast of NSW was undertaken to recommend directions for future investment. A native of Madagascar, fireweed is feared to cause poisoning of cattle, and it has spread and continues to spread throughout South Coast regions. From a theme-based synthesis of current technical and anecdotal information an action plan targeting landholders and involving information providers and weed enforcement agencies was formulated. The plan targeted critical information deficiencies; promoted success in the use of herbicides; and encouraged adoption of sheep and goats within existing cattle-based enterprises. By achieving efficiencies through changing the way current practices are implemented; and focussing on some of the major adoption barriers, the plan will be of considerable short and long-term benefit to industry.

# Executive Summary

### Why the work was done

Fireweed (*Senecio madagascariensis*) occurs throughout the beef-producing areas of coastal NSW. Because it contains chemical compounds collectively known as Pyrrolizidine alkaloids (PA's), which pose a threat to livestock health, it is viewed with great concern. This is particularly the case on the South Coast, where fireweed continues to spread from core infestations, which themselves have only recently become prominent.

The project bought together data and information relating mainly to fireweed, and where appropriate and in less detail, unpalatable types of African lovegrass (*Eragrostis curvula*), as a basis for planning and prioritising future delivery actions that may then be taken up by local Authorities such as the Southern Rivers Catchment Management Authority, NSW Department of Primary Industries agronomists, local weed authorities and other interested groups.

### What was achieved?

The review identified three main themes: (i) spread, biology, and impacts of fireweed on the South Coast; (ii) impacts of fireweed on production, including a consideration of aspects relating to PA's; and, (iii) Options for reducing the prevalence of fireweed.

Business opportunities that the weed presented were also outlined.

On a theme-by-theme basis, a synthesis Chapter examined the extent to which current knowledge was deficient, and listed some of the key unanswered questions.

Prioritised delivery actions for tackling fireweed on the South Coast of NSW then flowed from this synthesis.

#### Knowledge deficiencies defined

i. Actions relating to Pyrrolizidine alkaloids and fireweed.

- Despite ill-founded fears to the contrary expressed in local South Coast media, food safety organisations have found no evidence that Pyrrolizidine alkaloids accumulate in animal products. (PA's are not absorbed into tissue; they are metabolised rapidly and their breakdown products excreted). The only action needed is for this to be highlighted in extension material.
- Of greater concern to coastal producers and an issue that has not been addressed, is the extent to which liver damage caused by low-level intake of fireweed PA's (chronic poisoning) impacts on the 'bottom-line' performance of beef and dairy industries. The specific contribution of fireweed PA's to 'coastal ill-thrift' in cattle, including better definition of the syndrome, would be a way forward.
- Aside from mortality observations where in some cases links have been assumed, there are few data linking animal health issues specifically to *S. madagascariensis*. It is therefore a serious but latent problem; or a seriously overstated relatively minor one. Commissioning of a science-based expert report that considered published and unpublished Australian data, would probably satisfactorily resolve this question.
- There is sufficient scientific data and corroborating anecdotal experience, to conclude that sheep and goats grazing fireweed suffer no adverse effects. No reports of death of sheep or goats were retrieved by a thorough search of the literature. (It is noted

that the suite of PA's in *S. madagascariensis* are dissimilar to that of *S. jacobaea*, which is the species on which most generalisations relating to animal health impacts are based).

ii. Actions relating to fireweed ecology and pastures.

The main unanswered questions relate to the spread of fireweed; its effect on South Coast pasture production, and benchmarking this; and the role of management in containing or reducing its prevalence.

iii. Actions relating to controlling fireweed

***Sheep and goats***. The main unanswered questions relating to controlling fireweed using sheep and goats related to provision of critical information in a handy format and provision of institutional support. Setting up facilitated learning networks; access to practical hands-on experiences; and exposure to 'can-do' approaches to the potential range of infrastructure issues were identified.

Developing a wider range of effective drenches for goats; the co-management of small flocks of sheep and goats for weed control within a cattle enterprise, and their effects on weeds and pasture health generally are areas of research need.

***Herbicides.*** The main unanswered questions relating to controlling fireweed with herbicides were to show that it could be done successfully and cost-effectively. There is a need again for handy information that leads landholders to being successful if they use herbicides.

### Prioritised delivery actions recommended

i. It would be a major advance to link goals stated in weed management plans, with the steps and tools to be followed/used by average South Coast landholders to achieve the goals. A framework for developing and implementing a consensus view across the levels of Government, and advisors, including rural suppliers is outlined. This process needs to precede or occur in parallel with the development of Recommended Best Practice Guides.

ii. Trials or demonstrations of options should focus on demonstrating and encouraging success through participation. Recommended actions include:

- Demonstrations of herbicide options, to explore the vital questions of timing, product and rate; and evaluate the longevity of single well-timed applications. These are the key questions that relate to the efficacy and economics of using herbicides.
- Surveying of landholders who have successfully integrated sheep and goats into their cattle-based production systems to examine issues such as flock management and economic performance.
- A survey across the range of South Coast pastures, focussing on weeds, within the framework of pasture productivity and health.

### Most critical missing information prioritised

For South Coast pastures, the most critical missing information is the link between the presence of fireweed and pasture production. Clearly, if its impact on production is marginal, and cattle do not graze it, then it is difficult to determine or economically evaluate its weed status. This data is also vital for establishing tolerance benchmarks, which flows through to all aspects of fireweed management.

For livestock, the most critical information is the specific contribution of fireweed to the poorly defined syndrome ‘coastal ill-thrift’. Because this syndrome is overwhelmingly general (and therefore useless as a diagnosis), it deserves to be thoroughly investigated.

Of equal importance for livestock is the specific risks and impacts of fireweed PA’s, particularly on sheep and goats. These data are also critical for setting pasture bench-marks and for establishing Recommended Best Practice.

### Benefits to industry

If they are adopted, the approaches to the fireweed problem outlined in the report will have two immediate benefits to industry. Firstly, by focussing on success, it will lead to considerable savings in the implementation of herbicide-based control methods. The second benefit, which will be longer lasting, will be that it will accelerate adoption of sheep and goats, and their integration into cattle-based enterprises. This could be of considerable financial benefit throughout the region.

### Who can benefit from the results?

Outcomes of the project are intended to benefit weed control Authorities as well as the range of producers and small-farm landholders throughout the South Coast Region.

## Main recommendations and future directions

- Based on current information, develop well-targeted, detailed, realistic, success-oriented weed management plans for fireweed that are applicable to South Coast and adjoining shires which promote best practice.
- Resolve issues related to the impact of fireweed on animal health.
- Using sound experimental approaches, demonstrate the efficacy of using herbicides, focussing on the critical issues of herbicide type, timing, and application rate at a range of locations in South Coast districts. This project should include an assessment of the impact of fireweed on pasture production; and seek to benchmark tolerable fireweed levels in pastures.
- A single and relatively simple field experiment should be undertaken to establish the likelihood of fireweed becoming an invasive weed in adjacent Monaro Shires.
- Establish networks to extend the use of sheep and goats both as enterprises in their own right, and for fireweed control, focussing particularly on new landholders.
- A survey across the range of South Coast pastures, focussing on weeds, within the framework of pasture productivity and health.

# Contents

# 1 Background

This project is concerned with the impact and weediness of two regionally significant weeds that occur on the South Coast of NSW. They are:

- Fireweed, (*Senecio madagascariensis* Poir.) is the main focus of the work. It is a native of Madagascar; a winter to spring growing short-lived annual or biennial daisy (Asteraceae), which is feared to cause poisoning of cattle, and which has spread and continues to spread throughout South Coast regions (Figure 1).

  Fireweed seems most invasive on overgrazed or drought-ravaged pastures, and areas where groundcover has been disturbed by cultivation or herbicide application.

  (It is noteworthy that the *Senecio* genus (collectively referred to as ragwort), with more than 4000 species, is the largest genus of flowering plants in the world).

**Figure 1 Fireweed in May 2007, Bemboka district, Bega Valley NSW**

- African Lovegrass (*Eragrostis curvula* (Schrad.) Nees Complex) (Poaceae) will be mentioned in passing in the report. A native of southern Africa, it is a long-lived, perennial, summer growing ($C_4$) grass of variable habit and appearance. Lovegrass has been present in the South Coast district pre-1950, mainly in the Candelo-Kameruka rain-shadow area (Figure 2).

  African lovegrass is adapted to granite-derived acid sandy soils and it has spread relentlessly and is now extensively distributed as isolated plants, and patchy and dense paddock-infestations in many coastal pastures.

(It is also noteworthy, that *Eragrostis*, with >350 species, is the largest genus within the Chlorid (*Chloridoideae)* group of grasses. These grasses occur mainly in warmer subtropical regions that experience sporadic non-seasonal rainfall, interspersed by lengthy rainless periods (Johnston 1996)).

**Figure 2. African lovegrass in the Candelo district, Bega Valley NSW**

In addition to their impact on agriculture and the environment, weed control is a significant cost to local communities.

The Bega Valley Shire has developed regional management plans for 19 pest plants, however, almost half (46.7%) of the total expenditure on weed control programs in 2003-04 ($194,500) was allocated to African lovegrass and fireweed. In the adjacent Eurobodalla Shire, 16 priority pest plants have been identified. Expenditure on African lovegrass and fireweed in 2003-04 was $7,648, which represented 8.3% of total expenditure. (Other weeds in Eurobodalla, namely, blackberry and bitou bush accounted for the majority of the Shire’s expenditure on weed control in 2003-04).

It is reported that in both Shires areas infested with fireweed and African lovegrass have continued to expand

**Table 1**. (Data sources: Anon 2004)

**Table 1. Fireweed and African lovegrass in the Bega Valley and Eurobodalla Shires (Anon. 2004)**

| | Core infestations (ha) | Marginal infestation (ha) | Rare and isolated (ha) | Area of Shire affected | Success achieved (by 2004) |
|---|---|---|---|---|---|
| Fireweed - Bega Valley | 3,000 | 4,000 | 47,000 | 9% | Infestations increased in area and severity |
| African lovegrass – Bega Valley | 1,800 | 7,000 | 18,000 | 4% | Reduced area of rare and isolated occurrence |
| Fireweed – Eurobodalla | Nil | 65 | 650 | 0.2% | All infestation classes increased by 30% |
| African lovegrass – Eurobodalla | Nil | 30 | 270 | 0.1% | Infestations increased by 50% |

Clearly research or technical information that could improve the efficiency of controlling infestations of lovegrass or fireweed on public lands could result in considerable savings.

Local management plan for Fireweed control in the Bega Valley Shire prepared pursuant to Sections 7 and 8 of the *Noxious Weeds Act 1993* (Order 20) is given in Appendix 1.

Invariably, pastures of the region contain a range of other indigenous and non-indigenous plants, not viewed as weeds, but that are equally invasive. Some are viewed as a threat, some as a nuisance. Patterson's curse (*Echium plantagineum*), for example, was anecdotally reported as having been prominent during the early years (pre-1960) and it is currently a priority pest plant in both Shires. However, it is seen rarely in paddocks today. Mediterranean annual grass weeds such as Vulpia or silver-grass (*Vulpia bromoides*), soft brome (*Bromus molliformis*) and barley grass (*Hordeum leporinum*) have a benign but common presence and are not regarded as a threat.

It is beyond the scope of the work to examine the history of weed invasions in the Region, and anecdotally the record is far from conclusive. However, the development of the dairy industry, and its dependence on 'English' ryegrasses (*Lolium perenne*) and clovers (mainly white clover *Trifolium repens*) (Codrington, 1979), in an area that received the dominance of its rainfall in summer, were factors in the susceptibility of pastures to invasions by summer-growing weeds such as African lovegrass, and weeds capable of germinating during mid- to late-summer, which is the case for fireweed.

The Bega Valley's unique agricultural, social and political landscape has undergone considerable change and development since the first European squatters arrived in the district in 1829. Some of the challenges and process of settlement and the politics that have moulded the community of today were outlined by Codrington (1979), whose work has been extensively drawn upon in the following section.

## 1.1 Historical context

Along the southern coastal strip of NSW, clearing was complete over most of the land destined for agricultural use by the end of the 19th century. Forestry was then, and still is, an important regional industry. However, like other industries, it has undergone considerable change. Small sawmills, and individual operators have given way to large-scale, efficient, globalised operations that focus mainly on the export of bulk woodchips from the port of Eden.

On the cleared landscapes, dairying for cream for butter and cheese production, and to a lesser extent whole milk, was the major agricultural industry up to the early 1970's.

### 1.1.1 The predominance of the dairy industry

The free selectors that followed the squatters into the district during the 1860's bought with them Australian Illawarra Shorthorn (AIS) cattle, and it was these cattle, the small acreages they were allowed to settle (16 to 130 ha), and the technology of their agriculture that set the social and political agenda for the ensuing 150 years. Weeds, and the ability, willingness and capacity of State and local Authorities, and of individuals to deal with weed threats are part of this socio-economic matrix.

According to Codrington (1979), there were 7 butter and cheese factories, and 47 on-farm cheese factories in the Bega Valley in 1917. In 1922, there were some 800 mainly family-run dairies. Cheese and butter were the main exports because these could be transported to markets in Sydney by coastal steamer from Tathra without spoiling.

Although a milking herd of 100 cows was anecdotally an aspirational goal, pre the 1970's a typical family dairy of some 100 to 200 ha involved mechanical milking of <20 to 80 cows; it supported a skim-milk or whey based piggery and produced in addition, dairy-breed calves which were traded, and processed locally. There was a bacon and calf processing works where shops now stand in the main street of Merimbula; a pig abattoir operated at Eden and Moruya; weekly pig and calf markets were held adjacent to Kiss's Lagoon on the northern end of Carp St Bega, and regular cattle markets were held in Cobago.

Dairying was a profitable, relatively high-input enterprise, based mainly on pastures containing perennial ryegrass, tall fescue (*Festuca arundinaceae*) and white clover, usually supplemented by forage crops of oats, lucerne and corn. Kikuyu (*Pennisetum clandestinum*), which is an important naturalised species, arrived later, possibly after the seeding variety *Whittet* was developed and became more widely available in the 1970's.

Because weather conditions in late spring and through summer were unpredictable for drying hay, saved pasture, and crops, mainly maize and oats, were used for making pit-silage to offset forage quantity and quality deficiencies, which were important seasonal restraints to year-round dairy production. Many dairies on relatively hilly terrain inland from the coast had scattered small cultivation or garden paddocks of 1 to several ha for silage or forage crop production.

The dairy industry also required country that could be used to hold and grow-out replacement stock, dry cows, and breeding stock including bulls. This could be owned by the dairyman or leased; or dairymen could agisted stock or raise cattle on contract to non-dairy landholders.

Thus there existed a land use that was integrated with, but peripheral to the main industry. This land, which was generally lightly improved through the use of superphosphate (which up to 1974 was a subsidised input), carried native pastures (mainly kangaroo grass (*Themeda triandra*) and other warm season species on dry exposed slopes and weeping grass (*Microlaela stipoides*) and other cool-season species in higher rainfall areas, moist gullies and on shaded south-facing slopes.

Other agriculturally less valued species such as blady grass (*Imperata cylindrica* var. *major*) and barb-wire grass (*Cymbopogon* spp.) together with bracken and other ferns, and woody species such as *Acacia* and blackthorn (*Bursaria spinosa*) were also common, especially on steeper slopes. Landholders took steps to control or eradicate these species.

(For coastal dairies generally, the soldier-settlement benchmark in the mid 1940's was 100 cows on 250 acres (100 ha) (equivalent to a cow and calf to 1 ha). In the Bega Valley, this is still considered the 'safe' anecdotal production benchmark).

Without considering the detail, according to Codrington (1979), the various 'milk wars' fought between parties within and outside the Bega Valley for market share with the Snowy Mountains Authority, and in the Cooma, Queanbeyan, Canberra, Captains Flat and Goulburn markets in the 1950-60's, and later in the Sydney market; and the political pressures that were bought to bear, generally resulted in the strengthening of Bega Valley's whole-milk production position after the end of WWII.

Quality (butterfat and solids content of milk) was an important and marketable feature of the South Coast industry. To meet the butterfat needs of the growing butter and cheese industry, Jersey cattle replaced AIS, becoming the dominant breed after about 1900. As the industry became protected and thus more profitable through various Commonwealth and State interventions, production increased together with surpluses. This ultimately threatened its viability.

In the search for efficiency, which was reflected in market-share, gradual restructuring took place. As the trade in whole-milk increased in the 1950's, Friesian (Holstein) cattle became more common. Because of their higher milk production per cow (albeit at some cost in butterfat content), eventually they replaced Jerseys as the dominant breed. Bulk milk collection; centralised (but dominantly co-operative) processing; non-return to farms of whey and other by-products in milk-cans resulted in the demise of the family dairy-piggery. Post-1970, dairying became dominated by fewer, more efficient, larger, dairy-only Friesian-based operations.

The switch from cheese and butter to whole milk production in the 1950's and 60's, created pressure for producers to aim for year-round production rather than production peaks in summer and troughs in winter. In July 1962, the milk quota system was modified so that future production was determined on the basis of the supplier's lowest winter production. This required increased attention to supplementary feeding, especially during drought years such as 1954 (which was the 9$^{th}$ driest year on record (1898-2006).

It was during the early 1960's that lovegrass was first noticed in Candelo/Kameruka area. Some unconfirmed reports indicated that it could have been deliberately introduced, otherwise it possibly entered the district in grain, hay or processed feed, possibly from other districts such as the Monaro, or Cumberland plain west of Sydney, where by then it had already become established.

Rationalisation within the dairy industry saw pig markets and bacon factories closed; as roads were sealed bulk milk collections expanded. Old weatherboard dairies were largely condemned, and producers who could not afford to replace them left the industry.

Restructuring was cushioned somewhat by the proximity of the district to the developing cities of Canberra and Queanbeyan. Canberra had grown from a population of 41,000 in 1958, to 100,000 by 1967, and 126,000 in 1970. (In 1970, Canberra's projected growth rate was about 9,000/year). This created an expanding market for South Coast dairy products, and it attracted many former dairy farmers to seek work and education for their children in the near-by National Capital.

Investment in new concrete-brick herringbone dairies, upgraded equipment, storage tanks and the like, required producers that remained in the industry to become larger and more efficient, with increased emphasis on production standards. Co-operatives became politically active and more skilled at marketing, especially in the face of competition from margarine in the 1960's. Although the number of producers declined and smaller processing plants closed, as it became more centralised, Bega Valley's market share grew and dairy production increased.

Over the century, dairying benefited considerably from innovation. Changes in practice including the advent of pasteurisation, refrigeration, the cream separator, the Babcock tester (for butterfat content), mechanical milking; use of fertilisers and better species in pastures; new 'walk-through' dairy designs, use of poly-pipe in irrigation etc. have all impacted on its efficiency and profitability.

It has also been well supported institutionally both at State and Commonwealth levels. CSIRO's Dairy Products Research Section was set up in 1929 mainly to research manufactured dairy products; the Division of animal Health and Production contributed to animal health issues such as mastitis and contagious abortion.

NSW Government Agencies provided local experts in soil conservation, water management, dairy husbandry and agronomy; while on the South Coast, a research facility at Berry provided core research services to the local industry. Equivalent services were not provided to the beef industry or other dryland livestock enterprises, except from peripheral centres, such as Cooma.

Dairying was more lucrative and more intensive than beef production. Dairy farmers were disciplined in their use of time and resources; they were well net-worked through their co-operatives; they had access to expert assistance; their industry demanded high standards of pasture quality and health, and they had a tradition of systems, including weed control strategies, that was an integrated part of their operation.

By 2000, about 130 dairy farms remained in the Bega Valley supported by a single processing facility. Nevertheless, it has remained the main rural industry of the district, with production in 2000/01 valued at $37.9M. (More recent statistics indicate further declines in the numbers of diary farms (to about 95 at the present time (September 2007)); value of production statistics are not available, however).

### 1.1.2 The switch to beef

Beef farms, which came to occupy the largest proportion of the landscape, were less profitable and intensive, and tended to occur on less fertile, hilly lands, in lower rainfall areas away from the coast. Many beef producers increased their farm areas by purchasing smaller once family-run dairies, thus many single operators divided their time between non-contiguous areas. This presented difficulties for managing pastures and weeds.

Because beef farms were less productive on an area basis, costs were an issue, and inputs and investment in infrastructure was generally restricted to the most needy or urgent. The industry was also not sheltered from factors such as drought or market volatility, which reduced the ability of individual landholders to manage costs and debit levels. On the other hand, beef production was less time-intensive. This allowed producers to work off-farm, either in local industries, or activities that provided support to other landholders, for example, stock carting and contracting.

Prices for beef collapsed in the early to mid 1970's, with some producers recalling sale prices of well-finished steers of between $10 and $20/head. High interest rates, coupled with low prices and unsustainable levels of debit forced many off their farms. Survival depended on reducing input costs. Expenditure on sowing and fertilising pasture, animal health, weed control and other programs generally declined.

According to MLA data, beef cattle breeds on the South Coast comprise about 40% straight-bred British cattle, 30% dairy-beef crosses and the remainder beef-beef crosses. Most calving is in the July-August period. The traditional production system has been turning off 9-10 months old vealers for the domestic market; however, more recently, increasing competition for quality store cattle and yearlings allows producers to manage turn-off to meet changing market conditions.

Although beef cattle prices have fluctuated over the years, it is still generally a low-input activity. It occupies the greater proportion of the landscape, and with a value of $16.2M in 2000/01, it is the second most-important rural industry in the Valley. However, profitability is not high; it is an industry very sensitive to issues that may impact on its costs of operation. Another factor that sets the beef industry apart from dairying is that it is largely unsupported by the networking and lobby power offered by the dairy cooperative. It has been anecdotally reported that, provide debit levels were low, a minimum area of 1,000 ha would be needed in order for a beef producer to be financially self-sustaining.

### 1.1.3 Sheep and goats

Historically, sheep have also been important in some areas of the South Coast, particularly adjacent to the rain-shadow areas around Candelo, Kameruka and Bemboka, and areas with convenient access to the main markets for wool and sheep in Cooma and Bombala. The main enterprises have been straight Merino wethers for wool; and production of crossbred and Merino cross prime lambs.

Some larger properties such as Kameruka Estate, and family-run holdings ran large flocks of sheep (>2000 head) on unimproved and often-steeper classes of land. Over the last 10 to 15 years many of these properties have been broken up and sold, or their long-term owners have retired and taken their locally adapted knowledge with them.

### 1.1.4 People

Averaged over 5 year increments since 1981, the population across all coastal Local Government areas in coastal NSW increased on average by 1.2% (NSW State of the Environment Report 2006 (based on ABS statistics)). Population growth has been highest in areas close to Sydney and on the North Coast. Population of the Bega Valley Shire has increased from 28,268 in 1996, 30,703 in 2001 and 32,429 in June 2006, a rate of increase of 14.7% over the period. For the Eurobodalla Shire, the respective values were 30,433 (1996), 33,946 (2001) and 36,595 (2006), giving an increase of 20.2% over the period.

In the Bega Valley, the median age of the population has also increased from 38.4 in 1996, 41.8 in 2001, and 44.6 in 2006. This reflects the loss of young people from the district; the aging of the district population, and the attraction of the district for people seeking retirement or a new lifestyle.

## 1.2 Climate issues

The South Coast enjoys a maritime, mild climate. Winters are cool and relatively dry, while summers are warm to hot, and generally humid and wet. Although winter frosts can occur, mainly at low elevations in the landscape, they are generally not severe (Figure 3).

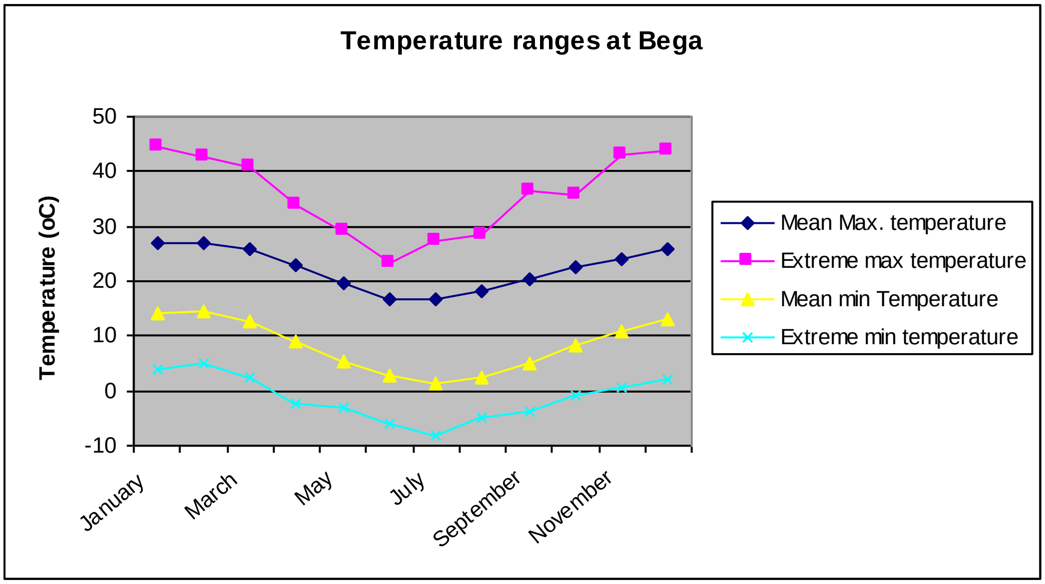


**Figure 3 Average temperature ranges recorded at Bega (1907-1994) (Station CBM 069002)**

The South Coast is generally regarded as a reliable rainfall area. Rainfall statistics for Bega are given in Table 2. Monthly rainfall is least in late winter and spring, and highest in summer.

The large discrepancy between the average and median (or mid-point) rainfall (Table 2) arises because whereas the average is affected by infrequent but extreme events, the median is not. Thus the distribution of rainfall is highly skewed. This is typical of regions that experience a high proportion of their rain as convectional storms.

**Table 2. Long term rainfall and evaporation statistics for Bega**

| Rainfall statistic | Jan | Feb | Mar | Apr | May | June | July | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average rainfall (mm) | 80.6 | 90.0 | 96.5 | 71.0 | 74.3 | 80.4 | 54.2 | 51.0 | 52.8 | 68.9 | 67.7 | 77.1 | 864.1 |
| Median rainfall (mm) | 59.4 | 49.0 | 56.6 | 38.6 | 36.4 | 42.1 | 27.2 | 27.5 | 33.2 | 52.3 | 52.4 | 54.4 | 792.8 |
| Highest rainfall (mm) | 431.8 | 730.9 | 669.9 | 409.5 | 635.9 | 689.0 | 354.9 | 326.6 | 240.0 | 369.4 | 301.4 | 324.6 | 1833.1 |
| Lowest rainfall (mm) | 1.6 | 0.8 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 1.0 | 398.9 |
| Average raindays/month | 6.4 | 6.2 | 6.4 | 5.4 | 5.3 | 5.3 | 4.1 | 4.6 | 5.4 | 6.7 | 6.9 | 6.6 | N/A |
| Average evaporation (mm) | 196 | 159 | 136 | 95 | 65 | 50 | 58 | 80 | 106 | 140 | 164 | 192 | 1436 |

Episodicity is a feature of the long-term (1889-2006) rainfall record. Such trends are highlighted using Cusum curves – in this case cumulative sums of deviations from the long-term average of

864.1 mm (Figure 4). Periods of above and below average rainfall are indicated by cumulative trends. These have been identified from Figure 2 and the statistics for the periods shown in Table 3**.**

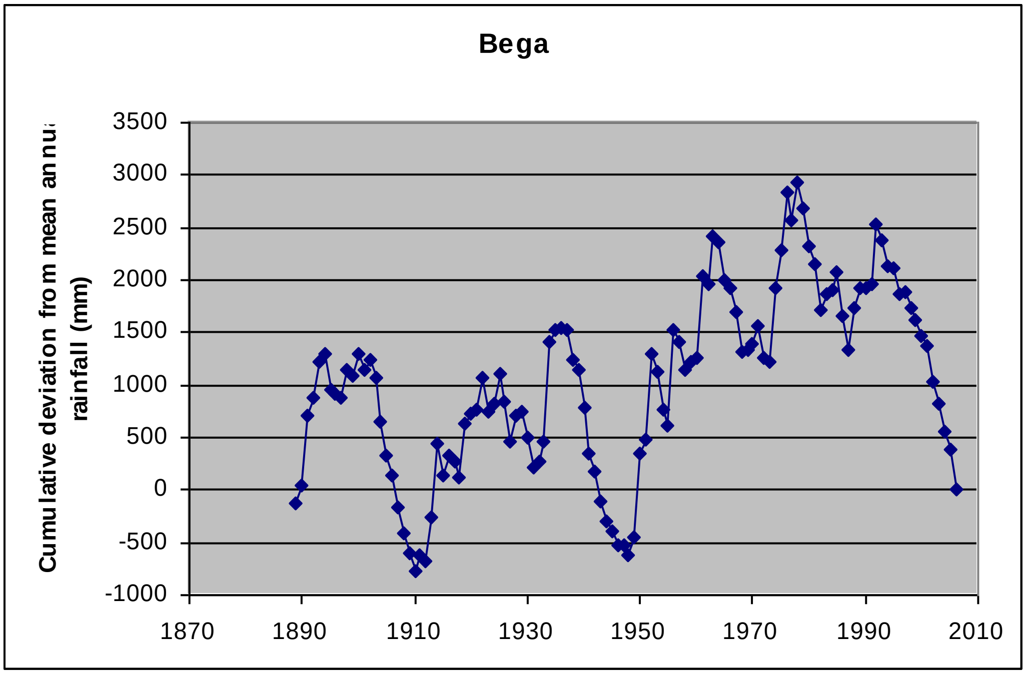


**Figure 4. Cusum curve for Bega (1889-2006). Persistent periods of average to above-average rainfall are indicated by rising Cusum trends; falling trends indicate periods of persistent average to below-average rainfall.**

The expansion phase of the dairy industry (1911 to about 1930) corresponded to a period of generally average to above average rainfall of 960 mm/yr. This encouraged confidence and investment. Land was cleared, pastures were sown, technology was adopted and stocking rates and productivity generally increased.

Rainfall during the period from 1937 to 1948 was below average, but apparently not calamitously so.

The lowest rainfall on record (409 mm) was recorded in 1941. Dry years (<600 mm) were interspersed by years of moderate rainfall (>700 mm), sufficient to allow forage to be conserved, for feeding out at other times.

With the exception of the drought year of 1954 (499 mm), the next 15 years (1949-1964) were very favourable for agriculture generally. Rainfall was high (averaging 1046 mm for the period) and numerous technological advances became available. New markets encouraged widespread sowing of European pasture species, application of superphosphate and the adoption of intensive management practices. Although greater numbers of cattle were carried on the available land, surplus production was beginning to create problems in the marketplace. Restructuring within the dairy industry was occurring, with the number of suppliers to the Bega factory declining from 223 in 1956, to 185 in 1965.

**Table 3. Rainfall periods identified from Cusum curves for Bega**

| Start Phase | End Phase | Years | Average rainfall for the period | Benchmark stocking rate (DSE/ha)[1] |
|---|---|---|---|---|
| 1889 | 1902 | 14 | 948.5 | 16.5 |
| 1903 | 1910 | 8 | 606.9 | 8.4 |
| 1911 | 1926 | 16 | 960.2 | 16.8 |
| 1927 | 1932 | 6 | 766.5 | 12.2 |
| 1933 | 1937 | 5 | 1109.1 | 20.3 |
| 1938 | 1948 | 11 | 664.1 | 9.8 |
| 1949 | 1964 | 16 | 1046.2 | 18.8 |
| 1965 | 1973 | 9 | 733.6 | 11.4 |
| 1974 | 1978 | 5 | 1200.7 | 22.5 |
| 1979 | 1987 | 9 | 681.4 | 10.2 |
| 1988 | 1992 | 5 | 1100.7 | 20.1 |
| 1993 | 2006 | 14 | 678.7 | 10.1 |
| | All years | 118 | 859.6 | 14.4 |

[1] Dry sheep equivalents calculated according to French, R.J. (1987) (Future productivity on our farmlands. *Proceedings of the* 4th Australian *Agronomy Conference*, La Trobe University, Melbourne, pp. 140-149).

The period from 1965 to 1973 was drier (period average 733 mm). The impact of 2 low rainfall years (1965 and 1968) was exacerbated by the large numbers of dairy cattle being carried and the need to continue reliable milk supplies into the expanding markets, especially Canberra. Dry weather and heavy demand for milk required local factories to source milk supplies from outside the district (Albury) and butter production by the Bega Cooperative reportedly reached its lowest level since 1942.

From 1975 to 1978, rainfall increased (1200 mm average over the 4 years) but many dairy farmers struggled to stay in the industry because of reduced incomes resulting from changes to marketing arrangements. Reduced rates of economic return saw a major reduction in the numbers of family-run dairy farms; cessation of butter-making at Cobago and other local factories; and political agitation for the entry of South Coast milk into the Sydney market. Political campaigning by dairy farmers was a major factor in the election of the Wran Labour Government in NSW in 1976. With the entry of South Coast milk into the Sydney market and other changes, confidence returned to an industry that had become smarter, leaner and much more productive.

A period of generally low rainfall occurred from 1978 to 1997 (period average 681 mm). This was followed by a brief wet period up to 1992 (period average 1100 mm), then a prolonged (14 year) drought that lasted up to the end of 2006, and which shows little sign of breaking (average rainfall for the period 678 mm).

During the span of these 29 years, sowing of pastures, and the regular use of superphosphate declined. Plant breeders were able to register their cultivars, which increased their cost somewhat. Fireweed also entered the district, anecdotally in fodder donated to the district from the Hunter Valley or North Coast, probably between 1965 and 1968 (the average rainfall over these 4 years was 597 mm – rainfall in 1965 and 1968 was less than 500 mm). Dry conditions from 1992 onwards have favoured its spread across the landscape.

## 1.3 Issues related to change

Over the past 35 years, the South Coast has experienced considerable social and economic change. Starting in the mid-1980's the dairy industry has restructured and aggregated, with many producers forced out of the industry turning to beef production on low input pastures, or pastures where inputs were no longer economically justified.

Today, dairy farms are large-scale increasingly efficient operations. Most are based on irrigated cool-season pastures; fodder conservation of summer and winter forage crops, and imported hay and supplements.

The industry is very sensitive to costs. Some dairy farms are no longer family-operated, but employ labour, and anecdotally it seems that as their parents retire, family members are not attracted to take up dairying as their occupation. This, together with the dependence of dairying on expensive inputs, including electricity and water used for irrigation, makes them vulnerable to further change. Rationalisation may therefore continue. This has implications for weeds as formerly irrigated or intensively managed areas returned to dry-land farming including smaller-scale agricultural production.

South Coast families have experienced a 'drift' of young people to urban centres, particularly Canberra and Sydney. In order to access services, people, including rural retirees, have also moved from district localities into centres such as Bega and Merimbula. Large landholdings have been broken up, and there has been an influx of 'new' people with new ideas, seeking 'hobby-farming' experience or lifestyle change, including retirement.

Many former dairies that had become beef farms were split up into smaller areas of between 5 and 30 ha. The attraction of the South Coast, its accessibility to Canberra (and Sydney via Canberra), and the desire of many urban people to 'have some land' has created new opportunities for growth in the Region. However, urban dwellers are largely absentee landholders, and in the context of managing the landscape, this presents problems, both for the 'real' farmers, as well as for themselves and their farms.

Selling off parts of holdings has provided a means for life-long farmers to realise the investment in their farms as a form of 'superannuation', encouraged somewhat by changes in taxation law.

Social changes are also obvious in the structures of the past. Silos stand empty and broken across the former Kameruka lands; disused roads serving derelict former family homes, old yards, broken fences, disused dairy infrastructure, and gates standing by themselves across one-time bridle-tracks are reminders of the past, and the people who have used the land and moved on.

On the other hand there has been re-invention. For example, old dairies have become shearing sheds, small-scale feed-lots, goat kiding sheds and studios or have simply been demolished to give way to a house or shed site. A former dairy has become a small-animal abattoir; saleyards have been re-located, and supermarkets now stand on the site of previous pig and bacon factories.

Roads have been up-graded, effectively shortening the journey between producer and consumer; tastes have changed – people come as tourists to visit and observe, rather than as timber or dairy workers, and now there is restructuring within the fishing industry, a marine national park, and the consequences will continue to force social-scale evolution.

As all these activities, especially the increased movement of people and goods within and from outside the Valley, increases its vulnerability and the likelihood of further weed invasions, fireweed may not be the last major weed to strike the Valley. It is the case that community awakening to the threat posed by both fireweed and lovegrass lagged considerably behind the arrival of the species in the district.

## 1.4 The South Coast today

The South Coast Rural Lands Protection Board (SCRLPB) undertakes surveys of the number of holdings with a rateable carrying capacity (in defined livestock units) each year. Up to 2005, properties were rated if their carrying capacity >50 livestock units (approximately equivalent to a DSE). In 2006, areas exceeding 5 ha were rated.

These data include all lands >5 ha, including subdivided land. The data is collected on a holding-by-holding basis, not a farm-by-farm basis, thus it does not discriminate between singly owned properties, and cases where one landholder may own several non-contiguous areas. More landholdings are identified in the SCRLPB survey than Australian Bureau of Statistics (ABS) surveys, which are based on ‘Agricultural Establishments’.

In 1993/94, ABS identified 437 agricultural establishments in the Bega Valley. Numbers had declined to 417 by 2000/01. In comparison, in 2000, the SCRLPB identified 2156 rateable landholdings (SCRLPB statistics for 1993/94 were not available) (**Table 4**).

SCRLPB data, (**Table 4**) indicate a steady trend towards smaller landholdings, many of which would be defined by ABS as non-agricultural establishments. The median area of landholdings declined by 12 ha between 1997 and 2006. Ninety percent of holdings were less than 174 ha in 1997. This had fallen to 148 ha by 2006.

Differences between the average and median areas reflect that the average is influenced considerably by the size of the relatively few large landholdings. This creates a statistically skewed impression of the more usual size of holdings.

SRLPB data (**Table 4**) indicate that from 1997 the numbers of beef and dairy cattle increased up to 2002-03, but have declined since, possibly in response to dry conditions (and water restrictions); the number of sheep have fluctuated somewhat but did not change markedly, while the numbers of goats increased steadily from 2000 onwards.

## 1.5 Impacts on the pasture base

For South Coast pastures, the 1970’s seemed pivotal years. It was during this time that the superphosphate bounty was discontinued; kikuyu was sown from seed; Glyphosate and selective herbicides, including Metsulfuron methyl, Flupropanate and Bromoxynil were developed or released. African lovegrass also emerged as a troublesome weed in the Bega Valley in the 1970’s, and Great Britain entered the European Common Market, which impacted greatly on importation of dairy products from Australia.

**Table 4. Land area and livestock statistics for the Bega Valley Shire (derived from South Coast RLPB data).**

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total holdings | 1850 | 1936 | 2015 | 2101 | 2156 | 2211 | 2225 | 2309 | 2533 | 2429 |
| Total area of holdings | 133120 | 137259 | 141315 | 144571 | 142520 | 149028 | 145468 | 149912 | 153286 | 144168 |
| Av.Area | 72.0 | 70.9 | 70.1 | 68.8 | 66.1 | 67.4 | 65.4 | 64.9 | 60.5 | 59.4 |
| Median area | 40.0 | 39.0 | 39.0 | 39.0 | 36.0 | 36.0 | 35.0 | 36.0 | 30.0 | 29.0 |
| 10 percentile | 9.0 | 8.0 | 9.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 7.0 | 7.0 |
| 90 percentile | 174.0 | 175.0 | 171.2 | 164.0 | 156.5 | 161.0 | 155.0 | 157.0 | 151.8 | 148.0 |
| No_Beef | 38716 | 33286 | 31907 | 33357 | 35505 | 40675 | 40666 | 34872 | 36912 | 36090 |
| No_Dairy | 28863 | 28435 | 32138 | 29942 | 30650 | 30166 | 29397 | 29232 | 26481 | 23408 |
| No_Sheep | 17882 | 19797 | 23703 | 24771 | 23678 | 24398 | 22061 | 20538 | 21984 | 21308 |
| No_Goats | 1604 | 1677 | 1281 | 1419 | 1726 | 1896 | 2297 | 2476 | 2570 | 2769 |

Somewhat in response to the economic ramifications of ending the superphosphate bounty in 1974, the pasture base of the South Coast reverted to a more ‘naturalised’ type, with fewer farmers sowing exotic pastures. It was the general experience that due to low winter rainfall, insect damage and overgrazing, non-irrigated temperate pastures sown for beef production did not last (Harry Kemp, personal communication 2007).

In addition, climatic uncertainty, the cost involved in sowing pastures ($500-$700/ha), and the explosion of a wide range of annual and perennial weeds that occurred in response to land disturbance, made pasture sowing for beef production increasingly uneconomic.

Except for several demonstration-style investigations, including investigations targeting chemical control of African lovegrass; and trials of specific herbicides carried out by chemical companies and sponsored by local rural agencies, few non-dairy focussed agricultural research projects have been conducted in the Bega Valley. Farmers have thus little first-hand knowledge of the benefits or outcomes of research specifically targeted at their problems. Amid their overwhelming concern about the drought, cattle prices and escalating costs, it is difficult for many producers to benchmark in their mind’s-eye, concepts such as: ‘encourage more competitive pastures’, or, ‘integrated weed management’.

Cost is a major issue. In the early 1980’s the Department of Agriculture conducted demonstrations of the farm-gate value of superphosphate application coupled with sowing subterranean clover (Harry Kemp, personal communication 2007). As most landholders were wary of increasing their cost-base at a time of low and uncertain livestock and milk prices, although awareness was heightened uptake was limited.

As the amount of superphosphate applied generally to pastures declined, its application by air dwindled to the point where it was not viable to maintain a service. Fertiliser is now only applied by ground spreading, which is a significant barrier to applying fertiliser on the extensive hilly landscapes along the coastal hinterland.

There is no account of the introduction and use of kikuyu in the Bega Valley, however it is now arguably the most widespread and valuable naturalised exotic species. It has been sown using seed, and some landholders report rotary hoeing patches of kikuyu to provide sod to manually spread around their properties.

The advantages of kikuyu include, that it has extreme persistence during dry times; it grows rapidly in response to rain in summer; it provides excellent ground cover; in wet years it is capable of out-competing lovegrass, and that it builds up a reserve of pre-winter forage, albeit it of low quality. It also spreads by itself. Its main disadvantages are that its quality and growth rate are low in winter, and that it is susceptible to root-feeding insect larvae, namely, African black beetle and cockchafers.

Ecologically, and to a limited extent, anecdotally, at the interface between African lovegrass and kikuyu there is reason to believe that over time kikuyu will prevail. Kikuyu has arguably reduced the rate of spread of African lovegrass; it also reduces germination of fireweed during summer.

Although the impact and control of African lovegrass will briefly be considered, this report mainly focuses on developing on-farm management programs for fireweed. In the District, fireweed is considered to be a weed of great concern that may not have reached the limits of its distribution.

## 1.6 Linkages between past and present

The picture that emerges from this overview is of a community deeply influenced by its diary traditions, including the long history of cooperative marketing, purchasing and networking. Dairy cross cattle still feature strongly in the district, and if pastures are sown, they are similar to the once more widely sown temperate dairy pastures.

As dairying restructured, it was a logical and relatively easy step to switch to beef production. However, the size of many farms was not sufficiently large to be viable. This precipitated further changes, compounded by the economic circumstances of the day. Alternative enterprises, such as sheep and goats were not institutionally fostered, and many landholders were considerably daunted by the prospect of taking on something new.

Weed issues have been part of this mix. Low incomes from small farms limit the ability of landholders to deal with new or emerging issues such as weeds.

If success is not experienced, interest in the use of expensive herbicides wanes quickly. The need for off-farm work limits the time available; as young people leave the community and see their future elsewhere, flexibility is further reduced.

As more people come into the district, and take up smaller holdings, potentially, they will bring with them new ideas and approaches. They may also be better able to cope economically with the challenges they face. In order for them to be successful, they require access to knowledge that is accurate, complete, reliable, and handy.

These are some of the socio-economic issues that affect formulation programs to deal with these weed issues.

# 2 Project Objectives

The aim of this project is to develop a locally relevant, scientifically credible, prioritised action plans for tackling Fireweed and African Lovegrass on the Far South Coast. The report recommends directions for future investment in delivery actions for producers, with a focus on developing their skills, knowledge and confidence.

## 2.1 Development of the report

The report will be developed from the following:

- A technical report (literature review) on the existing knowledge (scientific and anecdotal) specifically packaged and targeted to meet immediate identified needs for fireweed control in the 2 production contexts - areas where inputs may be higher (eg fertiliser, irrigation and sowing of exotics) and native or unimproved country.
- Economic analysis of candidate fireweed management options in the differing production contexts to identify the most appropriate control approaches that could be progressed to demonstration in that production context.
- Develop best management guides for successful control for fireweed, for the 2 differing production environments (native pastures, higher input zone), based on a provided template. This would require a seasonal list of priority actions, and opportunities to exploit if finance and seasonal conditions permit, as well as remedial actions following monitoring of impact.
- Describe other products ("tools") that could be developed to support management practices. These may include a monitoring workbook; decision tree of control options etc.
- Propose a demonstration / delivery plan in the 2 key production contexts to assist in development of producer's skills, knowledge and confidence. It is anticipated that one aspect of this would be a "proof of concept site" where one or more of the most appropriate management methods in combination, is demonstrated, with a control. These sites must provide credible data and demonstrate cost effective success, and be a node for delivery of related control messages.
- Provide scientific input into development of case studies.
- Recommend actions for awareness, engagement and in service training of weed advisors.

# 3 General methods

- Both fireweed and lovegrass have been the subject of past research. Fireweed research conducted mainly on the North Coast and Cumberland Plain has resulted in information being presented in various forms, including as scientific papers, Theses, literature reviews, and extension material.

  The most pertinent of these information sources were critically examined in the light of the concerns and experiences of South Coast producers. Specific web-based searches were undertaken to fill gaps where information was lacking.

  Because the weeds had been reviewed in detail in the past, a 'soft-science' format was adopted in place of a strict, fully referenced work.

- Research on African lovegrass in Australia has been more dispersed, with studies being conducted in Western Australia, NSW (mainly by the Author in Wagga Wagga) as well as in ACT). Information sources include scientific papers, Theses, more general papers, as well as unpublished material.
- Committees of concerned landholders have formed in both the Eurobodalla and Bega Valley Local Government Areas (LGA) to lobby for action on Fireweed, mainly for the instigation of biological control programs. Meetings were held with both Committees to hear and note their specific concerns. Some individual members of the Bega Committee were interviewed separately.
- Weed control is the responsibility of Local Government; Officers from South Coast Shires, as well as the adjacent Cooma and Bombala LGA's were interviewed about their concerns, and in the case of Cooma, this involved a meeting and inspection in the field at a forest site near the top of Brown Mountain.
- With the assistance of the Catchment Management Authority, past and present Department of Primary Industries Agronomists, and a local Stock Agent, producers were identified and contacted, with the aim of obtaining a wide cross-section of experiences and enterprises, focussing particularly on producers with success stories to tell.
- Others who contributed to the study included South Coast Rural Lands Protection Board staff and members of the Bemboka Landcare group, whose focus when it formed was combating fireweed.

Information from these sources was used to define the main issues; highlight knowledge gaps; undertake economic analysis of options; and develop an action plan.

# 4 Results and Discussion

## 4.1 A review of literature pertaining to Fireweed

### 4.1.1 Sources of information

The aim of this review was to critically examine published works in the light of local (South Coast) experiences and concerns. No attempt has been made to re-review material that has already been collated and presented.

The most comprehensive investigation of fireweed in Australia was that of Sindel (1989), and it was on this work that the majority of current technical information is based. In 1998, Sindel *et al*. provided an updated in-depth literature review of the weed; while in NSW, publications by NSW Agriculture (Watson *et al*. (1994), and more recently the Department of Primary industries (Allan *et al*. 2001; 2005) present information in an extension format. Extension material relating to fireweed has also been produced in Queensland.

Information relating to the use of herbicides registered for use for controlling fireweed, including Material Safety Data Sheets, available as required by law, from respective chemical companies was also sourced. The impressions of local rural suppliers, regarding herbicide use were also sought.

A report commissioned by the Shoalhaven and Eurobodalla Councils (Morin 2003) in relation to the potential for biological control of fireweed is summarised in a separate section of this report, together with an update of the biological control program conducted in Hawaii provided by Kenneth K. Teramoto, Chief, Biological Control Section, Plant Pest Control Branch, Hawaii Department of Agriculture.

A specific area of concern that is not adequately addressed in the Australian literature is the toxicology of pyrrolizidine alkaloids, their impact on cattle, sheep and goats, and their risk to human health. This will be covered briefly in a separate section of the report.

A second specific area of concern is the spread of fireweed beyond the boundaries of its present distribution. This will also be considered in a separate section of the report.

## 4.2 Fireweed – past, present and future

According to Sindel *et al*. (1998), fireweed was thought to have arrived in Australia in the ballast of trading ships sailing via the Cape of Good Hope in Southern Africa. However, it could have arrived as early as 1788, with the first Europeans, who re-stuffed their mattresses, re-stocked their provisions and took on-board animals and hay in southern Africa on their way to Australia from Britain. The first specimen was collected near Raymond Terrace in the Hunter Region in 1918. The weed became prominent in the Hunter Valley, from where it spread throughout coastal regions.

In 1941, fireweed was declared State-wide noxious weed under the NSW Local Government Act 1919. It was removed from the noxious plants list in 1971, because its eradication and control was not feasible.

Noxious weed provisions of the Local Government Act 1919 were transferred to the NSW Noxious Weeds Act 1993. The Minister for Agriculture and Fisheries administers this Act; NSW Department of Primary Industries is the primary responsible Agency, while responsibility for enforcement on private land, and weed control actions on public land rests with local control Authorities. On the Far South Coast, this work is undertaken by Weeds Officers employed by the Eurobodalla and Bega Valley Shire Councils.

### 4.2.1 The spread of fireweed to the South Coast and its current weed status

Fireweed is said to ‘spread like wildfire’. However, in the Sydney Basin and North Coast areas, its spread was aided considerably by the export of lucerne hay (Hunter River lucerne) from the Hunter Valley to Sydney metropolitan dairies; horse-racing courses at Richmond, Warwick Farm, and Rose Hill; the dairying zones of the Cumberland Plain, as well as North Coast dairying districts.

The northern transport corridors linking Sydney and Brisbane also traversed the Hunter region. In retrospect, given the scope for human-vectored spread, the movement of fireweed to northern districts was inevitable.

The South Coast was more isolated from the regions where fireweed first became a problem. Dairying was more self-contained in terms of its feed requirements; the district was closer to sources of hay from Victoria and southern NSW, and with the Hume Highway the preferred traffic route, there was limited through-traffic from the north of Sydney to Melbourne.

Anecdotal evidence suggested that fireweed arrived in the Bega Valley in the late 1960’s in donated fodder from the north coast. The district was drought affected at the time; 1968 was the 5$^{th}$ driest year on record. Fireweed apparently began causing concern in about 1983, following another dry period (1982 was the second driest year on record). It has spread rapidly since.

Despite attempts to control fireweed, areas infested on the South Coast have continued to expand. In the Bega Valley, between 2000 and 2004, core infestations increased by 8%, marginal infestations by 3% and rare and isolated infestations by 13% (Anon. 2004). The total area of these infestations is estimated to be 54,000 ha.

The spread of fireweed to the Eurobodalla Shire seems to have occurred after it arrived in the Bega Valley. As of 2004, it affected some 715 ha (medium density infestation 65 ha; low density 130 ha, and scattered plants, 520 ha (Anon. 2004)). In 2004, the weed was reported to have increased by 50%, compared with the situation in 2000. Scattered are also observed in the Cooma-Monaro and Bombala Shire, but not at infestation-like densities.

Fireweed is a declared Class 4 weed in the Bega Valley and the adjacent Shires of Eurobodalla, Cooma-Monaro and Bombala. It is also a declared weed in the Kangaroo Valley, which is part of the Shoalhaven Shire (mainly to protect the ryegrass industry); as well as Tableland and South-Western Slope Shires, as far west as Boorowa and Young.

Order 19 of the Noxious Weeds Act 1993 specifies that for Class 4 weeds, the growth and spread of the plant must be controlled according to measures specified in a management control plan. The plan for the Bega Valley Shire is given in full in Appendix 1.

For the Bega Valley, the plan calls for the actions shown in Table 5.

In southern NSW, weed control at the Local Government level is organised into a regional group – The Southern Tablelands and South Coast Noxious Plants Committee. This group has produced a Regional Weed Management plan for fireweed, which aims to limit its spread and reduce its impact.

It is a problem that these planning documents fail the ‘usefulness’ test. They do not offer specific, reasonably fail-safe information, or even a source of where the information may be found. Thus, on the one hand, although landholders support action against fireweed, searching for information, or applying actions that fail frustrates them.

**Table 5. Management Plan control actions for fireweed specified in the Bega Valley Management Plan**

| Infestation situation | Control measures specified |
|---|---|
| All infestations | Chemical, mechanical, physical, cultural means or a combination of these methods.<br>All precautions must be taken to ensure that produce, soil, livestock, vehicles, plant and machinery are free of the weed prior to their sale or movement from infested lands. |
| Designated rare and isolated infestations (includes light or scattered infestations) | Fireweed must be suppressed and destroyed. |
| Designated marginal and core infestations | Fireweed must be suppressed within fifty metres of property boundaries, creeks and waterways, access roads and tracks in identified priority areas to complement adjoining management programs (including those on roadsides and public lands) and reduce the likelihood of spread onto neighbouring land.<br><br>Management may include an agreed grazing management plan. |

#### 4.2.1.1 Situations favoured by fireweed

Fireweed is essentially a pasture weed. It is relatively rare, or forms only occasional patches in undisturbed roadside situations or remnant forest vegetation even if the surrounding pastures are heavily infested (

**Figure 5**). Observations at several sites in the Bega Valley suggests that where tussock grasslands (e.g. remnant *Poa* spp. and *Themeda* grasslands) or patches of bracken dominate, fireweed seed lodges and cannot easily contact the soil surface, or gain sufficient exposure to promote establishment (it may germinate, but it fails to establish). Thus it is only found in inter-tussock spaces (Figure 6).

**Figure 5. Undisturbed kangaroo grass (*Themeda triandra*) roadside near Bemboka contains few fireweed plants compared to adjacent pasture, which is heavily infested.**

**Figure 6. Fireweed establishes with difficulty in grasslands dominated by tussocky grasses, in this case grazed poa tussock (*Poa labillardieri*). Removal of tussocks opens up the grassland, which increases opportunities for fireweed establishment.**

Fireweed is reported to respond to increased soil fertility, however, no data is available relating its dominance or productivity to soil nutrient status.

In unfertilised areas away from stock camps, for instance in grazed patches of kangaroo grass (*Themeda triandra*), although the density of fireweed may be high, its vigour is invariably low. In open areas occupied by weeping grass (*Microlaena stipoides*), fireweed density and vigour may both be reasonably high. Its density and vigour is usually high in fertilised pastures dominated by kikuyu.

Despite these general observations, perennial grasses considerably suppress fireweed establishment, compared with if the grasses were removed by cultivation, herbicide application or attack by sward-destroying insect larvae. The same is the case for areas in pastures where grasses lack vigour or persistence, for example, where soils are shallow and exposed. Dry north-west facing slopes and ridgelines are areas where fireweed plants, although relatively small in stature, are many times more numerous than in more favoured situations.

Thus within grazed pastures, variation in density, number of germination cohorts, and vigour may be considerable.

#### 4.2.1.2 The weediness of fireweed

Unlike determinate annuals whose growth stages are regulated by various physiological ‘triggers’, and whose life terminates abruptly upon flowering and seed maturity, fireweed is an indeterminate species. This is its most formidable weedy attribute.

Indeterminate plants grow in response to ‘windows’ – fireweed’s germination window is determined by soil water availability, light and temperature; in order to flower, its only need is for a long enough growth ‘window’; it will flower for as long as it grows, and it dies in response to extrinsic factors such as frost; it runs out of water (drought); it becomes diseased or it is terminally predated (usually by insects) or a combination of these.

Determinate plants are typically weeds associated with cropping, where synchronisation is important; indeterminate plants such as fireweed are more successful as weeds of pastures and horticulture - situations where flexibility and versatility are important.

Fireweed’s indeterminate growth is reflected in its capacity to germinate, grow, flower, set seed and die during most months of the year, and for a single plant to display all of its growth stages simultaneously (vegetative shoots, unopened buds, flowers, and spent capitula). It also enables it to respond flexibly to its circumstances. For example, plants may persist for just a few weeks, a full season, or several years.

To maintain seasonally dense populations, annuals such as fireweed depend primarily on replenishment and persistence of their seed-bank. In fireweed’s case because fresh seed is highly viable and most seed germinates within a season, maintenance of the seed bank is heavily dependent on production of the next seed-crop. Thus the seed-bank ‘rolls’ forward from one seeding event to the next, with individual seeds having low seed-bank persistence.

Successful annuals invariably produce large quantities of small seed (Harper 1990). Their primary strategy is to ‘saturate’ the environment with seed; secondary strategies, such as induced dormancy, hard-seededness etc. prolong seed bank persistence; while staged, *en-masse* germinations minimise the risk of not establishing a base population of new plants.

Because fireweed seed is very small (7.4M seeds/kg), it is difficult to study its seed dynamics in detail in the field. Thus the numbers and fate of fallen seed and other issues such as longevity of the seed bank; seed predation, and its behaviour at establishment is somewhat speculative.

According to Sindel (1989), ‘mature’ plants grown under experimental conditions may produce 230 capitula (individual flower heads), each containing >80 seeds (>18,000 seeds); allowing for 50% mortality, this gives 9,000 viable seeds/plant. Other data (cited in Sindel *et al*. 1998), suggests that in field populations, seed production may be significantly less that this (225 seeds/plant). Although considerable variation in the numbers of plants and capitula/plant can be observed in the field, it seems that even for the sparsest infestations, more than sufficient seed is produced each year to replenish the seed bank.

A major factor in the success of fireweed across the coastal beef-producing zones is its unpalatability. It is a common theme with weeds that low palatability enables them to complete their lifecycles and thus maximise the amount of seed they produce (eg. African lovegrass). As they start to dominate the landscape they also may reduce the competitiveness of other species due to them experiencing proportionally higher grazing pressure.

In his 1985 survey of NSW coastal areas, Sindel (1985) reported that fireweed was present on 90% of respondents farms; 43% of respondents believed it to be their worst weed; 10% thought it was under control, and that twice as many dairy farmers considered it to be under control compared to others.

The main reasons respondents considered fireweed to be a problem were: that they thought it competed with crop and pasture plants (57%); that it looked bad (45%); and that it reduced accessibility of available pasture (30%). In a ‘normal’ year, 37% of respondents did not believe that fireweed reduced overall productivity; 44% believed it reduced productivity by up to 10%; the remainder of respondents (19%) thought productivity was reduced by up to 50%. A higher proportion of respondents thought the effect of fireweed on productivity was greater in a bad fireweed year.

(As a cautionary note, these data represent landholder opinions converted into percentages. The real impact of fireweed on pasture productivity is confounded entirely by seasonal conditions. In ‘good’ seasons, when pastures are more productive/competitive, fireweed is suppressed; in ‘bad’ seasons pastures themselves are limited in their growth, which allows unpalatable fireweed to gain the upper hand).

In considering the results of his survey on a region-by-region basis, Sindel (1989) concluded that fireweed was perceived as less of a problem during the first few years of its arrival in a district, and substantially less of a problem after it had been present 30+ years.

In 1989, few Bega Valley landholders that were surveyed thought fireweed was likely to be a problem. Today, most landholders think it is a major problem. In contrast, in 1989, most north-coast landholders thought fireweed was a problem. Today, most view it as a significant irritation (Reg Kidd, personal communication 2007).

(High rainfall recorded in Bega in both 1988 and 1989 of >1000 mm may have had a bearing on the way fireweed was perceived at that time. With the district having now experienced its $14^{th}$ year of below-average rainfall, perceptions of fireweed are anecdotally very different).

The feeling on the South Coast can be summed-up by the words of one producer, who said that although he knew cattle did not graze fireweed, he “hated” to see it successfully crawling across his paddocks despite anything he did to try to stop it.

#### 4.2.1.3 Control methods

A range of methods has been employed to control fireweed, with varying reported levels of success (Table 6).

**Table 6. Success ratings for methods of controlling fireweed reported by Sindel (1985)**

| Control method | % respondents who attempted control and used the method | Level of success (% of respondents using the method) | | |
|---|---|---|---|---|
| | | Low | Moderate | High |
| Hand weeding | 74 | 37 | 29 | 34 |
| Slashing | 68 | 41 | 46 | 13 |
| Cultivation | 19 | 33 | 54 | 13 |
| Herbicide | 12 | 22 | 37 | 41 |
| Grazing sheep/goats | 35 | 21 | 37 | 42 |

Respondents that used hand-weeding and slashing, which were the most common control techniques, rated their success as low to moderate. The smaller proportion of respondents that used herbicide or grazing with sheep or goats thought they were generally more successful.

(In North Coast districts, sheep numbers as low as 1 sheep/ha have reportedly achieved satisfactory long-term control over fireweed (Keith Helyar, personal communication, 2007))

During the early phase of infestation by fireweed in the Bega Valley, some landholders report employing additional labour to hand-weed pastures in an attempt to arrest its spread. Hand weeding is widely undertaken and it is a major source of frustration, that despite the time and dedication involved, fireweed is not effectively controlled by the practice. At the present time, despite doubt of the long-term sustainability of the approach, weed authorities report that roadsides leading from the Bega Valley to Bombala and Cooma are regularly hand-weeded.

Interestingly, according to Sindel (1989), landholders that graze sheep or goats spent the least time controlling the weed; they also found it to be the least expensive control technique.

The data reported by Sindel (1998) (eg. Table 6) is based on survey information, and thus is somewhat subjective. It does not explain why fireweed has become a successful pasture weed through the coastal districts of NSW and southern Queensland. For example, is it because of its unpalatability to cattle; its copious seed production; capacity for seed dispersal; or establishment, or growth, or a combination of everything?

Successful intervention requires knowledge of these issues so control can be targeted to take advantage of the species' ecological weaknesses. To be successful, strategies need also to be designed around time-windows of when the weed is most vulnerable.

### 4.2.2 Distinguishing characteristics and biology of fireweed

Fireweed is the common name for a large number pioneer broadleaved species (not just species of *Senecio*) that occur throughout the word. All fireweeds seem to share three common attributes: they produce copious quantities of seeds; their seeds are fluffy or have an umbrella-like structure (pappus) that aids windborne dispersal; and when conditions are favourable, usually following drought, fire or disturbance, they spread like wildfire, hence their name. In some cases their name arises from their seeming predominance following fire. Other common names associated with fireweeds are ragwort, pilewort, groundsel and cotton bush.

The characteristics of different fireweeds, such as, where they occur, their rate or ability to spread; their effect on animals and their weediness, may be quite dissimilar to the fireweed referred to in this report (*S. madagascariensis*). They may also contain a different range of chemical substances, which may pose varying degrees of danger to different animals. Data relating to one fireweed may thus not apply directly to another.

The weedy fireweed referred to in this report is closely related in both appearance and taxonomy to the native variable groundsel *S. pinnatifolius* A. Rich (interchangeably referred to in literature as *S. lautus* Forst. f. ex Willd.) and in the past was often mistakenly identified as such.

Although Allen *et al*. (2005) lists the number of fireweed flower petals (13) as a distinguishing character, *S. pinnatifolus* may also have 13 petals (fireweed may also be observed to have one petal more or less than 13). Fireweed's most reliable distinguishing characteristic is the number of green, petal-like involucral bracts or phyllaries that form the 'cup' under the flower, which number 20-21 when viewed from below (Sindel 1989) (**Figure 7**). *S. pinnatifolus* has 15-18 involucral bracts. (Adequate identification of fireweed is aided considerably by using a 10X magnifier).

(See: http://www.lhccrems.nsw.gov.au/Weeds/herb13.htm).

(Fireweed is the only yellow-flowered daisy with a yellow centre that is likely to be found in coastal pastures (Figure 8); thus it is safe to assume that a plant meeting this relatively simple description is fireweed. If a suspected plant looks different to the many pictures of fireweed that are available, it is advisable to seek professional help in deciding an appropriate course of action).

#### 4.2.2.1 Germination, establishment and temperature responses

Although fireweed may germinate at temperatures between 10-30°C, its optimum range is 20-25°C (Sindel and Michael, 1996). Germinating fireweed seedlings are killed by frost temperatures less than about -4°C (equivalent to about -1°C screen temperature). Thus in the field, germination at low-range temperatures (winter, or in frost hollows) increases the mortality risk. Due to their shallow root system, and small size seedlings are also killed by competition and moisture stress. Germination at the high-end of their temperature range is therefore also risky.

Depending on conditions (mainly rainfall, but also temperature), fireweed germinates in waves (germination cohorts). Observations in the Bega Valley indicate that while a small but cumulative proportion of a total population can germinate in response to significant rainfall in mid to late summer (January to early March), the main wave of fireweed establishment occurs through March and April.

Fireweed can also establish in August and September, before summer-growing grasses commence growth, but because of competition, moisture stress in early summer, and insect and disease attack, the majority of these plants perish before flowering.

Germination is rainfall-induced; establishment is reduced where significant rainfall events (eg. >25 mm over several days) is followed by dry period of several weeks.

**Figure 7. The underside of a crushed fireweed flower showing 21 involucral bracts or phyllaries – the small green, striated, petal-like structures that make up the 'cup' under the flower.**

**Figure 8. Fireweed is the only yellow-flowered daisy with a yellow centre that is likely to be found in coastal pastures.**

Fireweed is phytoblastic – it has a light requirement for germination. Thus it germinates most rapidly and in greatest numbers when the soil surface is moist and the cover of vegetation is sparse. Good pasture cover reduces but does not eliminate the appearance of seedlings, but if conditions are suitable for germination in mid to late summer, and $C_4$ grasses such as kikuyu and native grasses are growing actively, the numbers of seedlings that establish are considerably reduced.

Fireweed seedlings are seen at first as 2 cotyledons (Figure 9). The stem of the seedling is red-coloured and this extends to the undersides of the cotyledons, and as they develop, the undersides of the first couple of true-leaves (see Figure 10).

Like other small-seeded species, fireweed has to quickly deploy photosynthetic tissue (in this case cotyledons) to offset the very small carbohydrate reserves in their seed.

**Figure 9. A young fireweed seedling (age – 12 to 24 hours). The first true leaf emerges from the growing point between the fleshy cotyledons. Note the distinct red colouration of the stem, which extends to the underside of the cotyledons, and later to the underside of the first few true leaves.**

In Cumberland Plain populations, the highest proportions of cohorts that survive to flowering germinate early (before winter). Plants that germinated from September onwards, rarely reached flowering age (Sindel and Michael 1996).

Averaged over the whole population of seedlings, Sindel and Michael (1996) estimated that nearly 50% of seedlings died within a month of establishment. This depressed the mean life expectancy of a single plant to about 1.5 months.

In summary, fireweed produces massive numbers of seed; especially where populations are dense. Under conditions of relatively sparse pasture cover, these seeds germinate mainly in autumn, in massive numbers also. Because they then perish in massive numbers, numbers of plants that survive to flowering are relatively low.

In the Bega Valley, at the end of its growing season, from all the seeds that fell to the ground the previous year, and that germinated and established, flowering and seeding field populations commonly consist of around 20 adult plants/$m^2$. The contribution of these plants to herbage mass has not been measured, but is likely to be in the vicinity of 200 to 500 kg.DM/ha. In a good spring, it is usually observed to be less; in a dry spring relatively more. (This apparent contradiction seems due to higher competition from other plants in the pasture in a wet spring; and lessened competition coupled with grazing avoidance when spring is dry).

True leaves emerge from the growing tip, one after the other as the stem elongates. Thus they are ‘alternate’ on the stem. Seedlings are most susceptible to herbicide application at between the 4 and 10 leaf stage, which is reached after 2-3 weeks of reasonable growth (Figure 10).

Germination and establishment is observed to be much higher where pastures, or patches in pastures are overgrazed or are sparse, owing to their position on the landscape. For example, density of fireweed is often high across exposed ridgelines, where soils are shallow and grasses offer less competition. Establishment is also less in frost-hollows or frost benches that occur in low positions in the landscape. Thus across paddocks, considerable variation can be observed in fireweed density, as well as in the numbers of germinating cohorts that make up successive populations.

For areas prone to invasions, if the competitiveness or cover of pastures or competing grassland is reduced in late summer, by over-grazing, cultivation or herbicide application, fireweed germination and establishment increases considerably.

**Figure 10. A single cohort, or cluster of fireweed seedlings in an area of kikuyu pasture that was sprayed with glyphosate (left). Between the 4 to 8 true leaf stage (right) seedlings are particularly susceptible to low-rate herbicide application.**

Although fireweed has taproots, its root system is shallow (10-20 cm) and finely branched (Figure 11). An ‘S’ shaped bend at the junction of the root and main stem is easily broken, leaving the root system intact and able to re-shoot from nodes at or under the soil surface.

**Figure 11. Initially, fireweed has a single primary tap-root. As it gets older, this is supplemented by additional roots as well as a fine network of surface roots. The 'S'-shaped bend at the soil surface allows the plant to contact the ground and establish adventitious 'feeder' roots. New shoots usually arise in the vicinity of the bend, and if plants are broken off, these give the appearance of vigorous juvenile plants.**

Because its root system is shallow, under dry conditions, fireweed is subject to considerable moisture stress, which will delay its development. Prolonged moisture stress can kill both seedlings and well-established adult plants. Under favourable moisture conditions, at points of contact with the soil, stems can form adventitious roots and thus re-anchor. Severed plants may also re-anchor to the soil; however, this is unlikely to be a major factor in its persistence.

Fireweed sheds large quantities of light, highly viable seed, most of which settles to the ground within 5 m of its parent plant. (Most of the seed falls within centimetres of where it was released, seed numbers decline rapidly with distance). The feathery pappus (umbrella-like structure) facilitates wind-borne dispersal (Figure 12), but not all seed remains attached to its pappus. Although it is anecdotally believed there is no barrier to the distance seed may be blown, there is little scientific evidence to suggest that it blows far.

Fireweed seed seems to be highly viable, thus in any one year, most seed that is able to germinate will do so. It usually flowers, distributes seed and dies before the following Christmas. A high proportion of shed seed is viable at the time it is released, thus seed from successive populations may germinate in a single year, although in practice, on the South Coast this is improbable.

(In assessing the efficacy of attempts to control fireweed, it is important to consider impacts at a cohort level. For example, some treatments may affect only one or several cohorts. Evidence of a continuing problem, or ineffective treatment may be the result of a single tolerant or acclimatised group).

**Figure 12. A fireweed flower shedding seed. The feathery pappus aids wind dispersal, however, most seeds from an individual plant falls to the ground within a few metres of where it is released.**

#### 4.2.2.2 Impact of frost

It is well documented that frost limits fireweed establishment (Sindel 1989).

Fireweed seedlings of less than 4-6 leaves (2-4 week old plants) are killed outright by frost temperatures of less than about -7°C (about -3°C minimum screen temperature) (Sindel 1989; B. Sindel personal communication 2006). Although older plants (>10 weeks old) may be damaged by low frost temperatures, they are rarely killed and may re-shoot, flower and set seed the following spring.

Although locally cited to be evidence of genetic alteration, frost hardening, or the development of frost resistance, is the result of exposure to low temperature conditions, rather than an expression of genetic adaptation or mutation.

In situations subject to frost, typically cohorts older than about 4 weeks at the time of frosting may be damaged but survive, while small, younger seedlings perish. In spring, these populations may be observed as single cohort populations, of similar size and having somewhat synchronised development characteristics, perhaps with a smaller cohort of mid-spring germinants.

At 2 sites near Bemboka, frost benches adjacent to Sam's Corner Creek recorded respectively, 5.2 and 5.0 plants/m$^2$ in September 2007. This compared with adjacent pasture areas, where the average density was 21.8 plants/m$^2$. While in the frost hollows a single, relatively old cohort was in evidence, together with a sparse population of recently established plants, in the paddock, up to 4 cohorts were identified (Figure 13).

**Figure 13. A frost bench beside Sam's Corner Creek near Bemboka. In the more heavily frosted foreground, only a sparse single-cohort population of about 5 fireweed plants/m$^2$ survived. A contour-like boundary defines the extent of the apparent frost effect.**

#### 4.2.2.3 Survival of older plants into the following year

In some years, a proportion of older fireweed plants may survive the following summer. Although usually decrepit, these plants may set seed in autumn and die, or continue to survive through winter, and set seed and senesce the following spring. The majority of these old plants lack vigour and usually show signs of insect and disease damage. Because they are not easily killed using herbicide, their presence in large numbers can carry seed forward, and this impact on the efficiency of herbicide-based control strategies.

Sindel (1989) noted that although slashing fireweed during early stages of growth reduced its survival, slashing late increased the proportion of over-summering plants. Observations of attempts to control fireweed in the Bega Valley suggest that slashing post-flowering plants, or applying herbicide (Bromoxynil) at a late stage of growth increases the proportion of plants that continue to grow into the following year (Figure 14).

Slashing by itself after the end of July helps to perpetuate fireweed (Figure 15). This leads to ineffective control attempts in subsequent years.

**Figure 14. Reinvigorated fireweed plants sprayed with bromoxynil in mid-spring 2005, photographed in May 2006. Most plants re-shot from the base of the apparently dead stems.**

**Figure 15. An apparently young vigorous fireweed plant (left), photographed on 26 October 2007, 2 weeks after slashing. Slashing removed diseased older shoots, which were replaced by new growth of both shoots and roots (right). (Adjacent plants that were not slashed were moribund, diseased and decrepit, indicating that they were close to the end of their life).**

Observations at one site, which was also exposed to frost, of plants that were sprayed and slashed after they commenced flowering in August 2007, found that although all plants appeared dead several weeks after spraying, by mid-September the average density of plants that had re-sprouted was 5.0 /m$^2$; the number of plants that remained dead was 2.6/m$^2$.

Usually, plants that respond in this way seem invigorated; they are relatively resistant to further herbicide application and they are capable of producing significant quantities of seed in the autumn following treatment.

Many fears are held in southern districts regarding the capacity of fireweed to spread and dominate pastures. Although it produces copious quantities of seed/plant, and thus for dense infestations, many seeds/ha, its seed production capabilities are not reflected in the density of plants usually found in pastures or along roadsides.

For instance, near Bemboka, in September 2007, while undisturbed kangaroo grass roadside verges contained practically no plants at all, the numbers of flowering plants in adjacent pastures, judged as heavily infested, averaged about 20 plants/$m^2$. This number of adult plants represents a very small proportion (about 0.16%) of seed-bank estimates of 12,000 seeds/$m^2$ given in Sindel *et al*. (1988).

Fireweed seems to be neither an efficient nor apparently aggressive invader, it is simply, persistent in its quest.

### 4.2.2.4 Population numbers in perspective

Like many weeds, survival of fireweed through successive generations is a numbers game. Figure 16 presents a theoretical survival curve for fireweed, based on data in Sindel (1989) and Sindel *et al*. (1988).

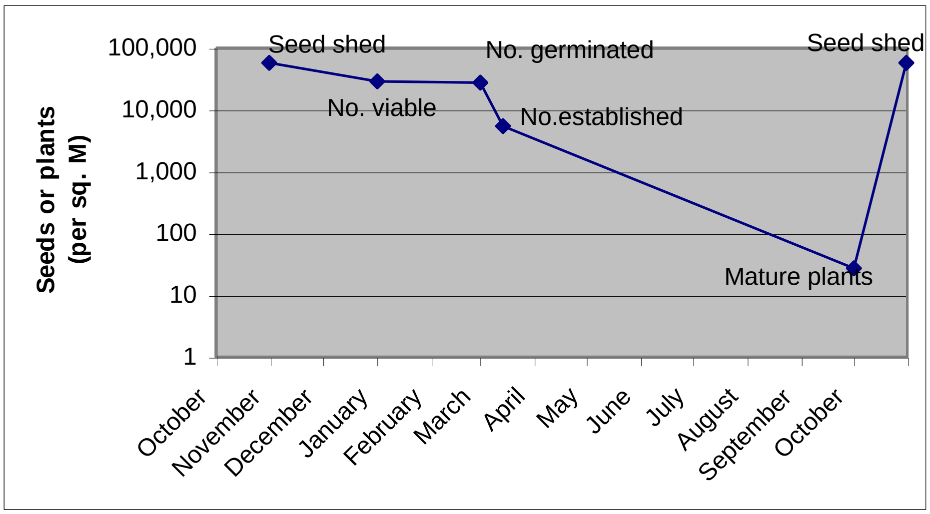


**Figure 16. A theoretical survival curve for fireweed based on Sindel (1989) and Sindel *et al*. (1988)**

Because most germinants are destined to perish, it is not important that >80,000 seeds/$m^2$ may be shed; or that these may give rise to >1,000 seedling plants/$m^2$. Natural fireweed populations suffer vast reductions in plant numbers between establishment and maturity due to competition from other species, competition between individual fireweed seedlings, and attack from insects and disease.

Because they are the plants that propagate the next generation, the most important link in the survival chain is the 20 or so mature plants/$m^2$ that shed seed. Reducing the size of the post-establishment population *en-masse*, or targeting the capacity of mature plants to set seed seem to be the main options to impact on the population.

#### 4.2.2.4.1 Climate impacts on the dynamics of fireweed populations

Throughout the areas where it has become naturalised, numbers of fireweed plants that germinate, and numbers that survive to flower and set seed, vary markedly from year to year.

A ‘good’ year for fireweed is marked by a dry late-summer to autumn period, which reduces the competitiveness of perennial grasses and promotes their overgrazing, followed by a distinct autumn break from late February onwards, with rainfall continuing into winter and spring. This combination of circumstances results in large adult fireweed plants and the production of copious quantities of seed, which potentially sets the stage for a major problem the following year. The risk to livestock under this scenario may be moderately high if pasture growth in spring is low, and fireweed makes up most of the available herbage at that time.

An ‘average’ fireweed year occurs when soil moisture is available through summer and into autumn, and pastures remain active until early winter. Pasture growth in this case suppresses and offsets the presence of fireweed, and provided sufficient pasture is available in spring so that susceptible animals are not forced to graze it, the risk to susceptible livestock is low.

Fireweed experiences a ‘bad’ year when all the conditions for its *en-masse* germination and establishment are met (low autumn groundcover; distinct early break (rainfall > 15 mm over several days from late February into autumn), but there is little or no follow-on rainfall. Depending on how well seedlings have developed, rainless periods (rainfall less than 4 mm/day) of 14 to 28 days have been observed to result in considerable seedling mortality at Bemboka. Established seedlings and even adult plants can be observed not to survive persistent dry conditions, which considerably impacts on their seed production capability. While presenting numerous challenges for landholders, extreme and prolonged drought conditions may considerably reduce fireweed populations in subsequent years.

#### 4.2.2.5 Mobility and spread of fireweed

Mobility of fireweed over the landscape is facilitated greatly by the movement of vehicles, people, produce and hay. Long-distance dispersal has mostly been linked to the movement of hay during drought periods, or machinery.

It is not unusual when driving across fireweed-infested paddocks in late spring for seed to be drawn up into radiators; and through vents and open vehicle windows to the extent that it can be irritating. It may also stick to mudflaps embedded in mud and cattle dung. Seed can thus be moved hundreds or even thousands of kilometres in several days along transport corridors.

(In March 2005, the Author observed fireweed germination in soil transported from Bega to Canberra on the underside of a vehicle. Although seedlings reached the 6-leaf stage, they failed to survive the first major winter frost).

(Arguably, although dispersal at a local (paddock) scale is wind-vectored, the spread of fireweed across districts and regions is mainly by means of vehicles, hay, produce and machinery. Inter-regional spread seems to have been due to hay movements; vehicles and people are more likely implicated in the intra-regional spread of the weed).

(Underscoring the importance of man-vectored spread, according to Gardner *et al*. (2006), fireweed was suspected of entering Hawaii in contaminated groundcover seed imported from Australia).

Because of the impracticality of dealing with the vectored spread of fireweed, over the 20 or 30 years that it has been present in the Bega Valley, it has probably been spread, and continues to be spread, well beyond its adaptive range.

Factors that operate to reduce its competitiveness include lack of opportunity for pre-winter germination coupled with low winter temperatures and frost away from the coast; low pasture growth rates in spring coupled with the prevalence of sheep away from the coast, notably across the Monaro, the Tablelands, north-east Victoria and the Riverina; and the prevalence of stable, tussock-type grasslands, or remnant woodland communities along roadsides.

Although isolated fireweed plants have been reported and observed along roadsides in LGA's west of the Bega Valley; and that in isolated circumstances (notably land disturbed by road works, pasture sowing or forestry activities) it may occur as low-density (<1 plant/$m^2$) communities, there is no evidence of it reaching infestation-like proportions.

#### 4.2.2.6 Reproductive biology and hybridisation with *S. pinnatifolius*

Hybridisation with native *Senecio* spp. has been raised on several occasions by the Bega Valley community within the context of better-adapted 'superweeds' evolving from current fireweed infestations. There are occurrences in Australia, and elsewhere in the world where hybridisation between species of *Senecio* have resulted in hybrid forms and 'new' species, and there are suspected to be genetic mechanisms that could result in hybrid fireweed types (Peter Prentis, personal communication 2007). However, despite the close taxonomic relationship between fireweed and *S. pinnatifolius*, it does not follow that a successful hybrid form is likely, and more importantly that it would survive or be competitive in the environment.

A study of the outcome of hybridisation between fireweed and native *S. pinnatifolius* has recently been published by Prentis *et al* (2007).

At the interface between populations, it seems that hybridisation is both likely and frequent. Of three possible outcomes, namely, enhanced weediness due to hybrid vigour; evolution of new lineages; or a decline in numbers of hybridising species due to the production of non-viable seed, the latter has been shown to be the case. Population decline due to the production of non-viable seed was weighted against *S. pinnatifolius*, because its fecundity or reproductive capacity was less than fireweed.

In other words, although these two species cross-pollinate, the resulting hybrid seed is non-viable. In an ecological sense, as its relative frequency increases, fireweed is predicted to overwhelm *S. pinnatifolius* because more of its seeds are true, fertile, fireweed seeds than they are non-viable hybrid seeds. On the other hand, *S. pinnatifolius* produces increasing numbers of non-viable hybrid seed as its exposure to fireweed increases. It is a common outcome that interspecific crosses between species having different chromosome numbers produce dysfunctional or fatal genetic outcomes.

Fireweed is an obligate out-breeder (Sindel *et al*. 1998). It does not produce seed if seed heads are bagged (to prevent insect pollination) or if self-pollinated. Sindel *et al*. (1998) did not comment that this might hinder rates of spread, or impact on the weediness of single outlier plants, but it may hold the key as to why initial invasions seemed to take considerable time to become infestations.

Chromosome counts of 2n=20 were recorded for a range of specimens of fireweed from Australia and Madagascar, while a diversity of *S. pinnatifolius* specimens recorded counts of 2n=40 (Radford *et al*. 1995 (cited by Sindel 1989)). Hybrids produced by artificial crosses in the laboratory were sterile, with no mature fruits being produced from hybrid plants under open pollination tests (Sindel *et al*. 1998 (citing several Authors)).

Work on hybridisation is continuing.

## 4.3 Impact of fireweed on production

### 4.3.1 Pasture production

Because in spring, fireweed has bright yellow flowers, and it has spread widely across the Bega Valley landscape it is easily observed, and thus perceived to have had a major negative impact on production. Although on the North Coast, Martin and Coleman (1977) found that it had little influence on the productivity of $C_4$ grasses, Sindel (1998) reported that the yield of grazing oats may be reduced by over 70%, and the grazing area by 60%, by 40 plants/$m^2$ of fireweed.

In a further study, Sindel and Michael (1992) reported that as fertility (nitrogen and phosphorus) was increased in a replacement-series pot experiment, relative growth of fireweed increased at the expense of growth by Saia oats. By suppressing the oats, fireweed enjoyed an aggressive advantage.

According to Sindel (1998), despite a significant ($P<0.05$) increase in pasture growth of about 60% in one experiment where fireweed was removed using a selective herbicide, other experiments that aimed to quantify the impact of fireweed on pasture production were inconclusive.

There are three difficulties with reconciling these experimental data with observations of the behaviour of fireweed on the South Coast.

The first difficulty is that most infested pastures consist of perennial species. In the field, these do not start growing and competing with fireweed at the same time, which is the case in pot experiments. (Most South Coast pastures are also not newly sown; they are generally not heavily fertilised; and they contain a predominance of summer-growing rather than temperate ($C_3$) grasses).

Drought is also an issue, and when pasture growth is limited by dry conditions, removal of fireweed may not necessarily result in increased pasture growth. On the other hand, evidence suggests that under non-drought conditions pastures containing perennial species compete against fireweed more successfully. Thus in more ‘normal’ rainfall years, fireweed may be less, or perceived to be less of a problem.

The third issue is that it is both relatively simple and cost-effective to use herbicides containing Bromoxynil to remove fireweed from newly sown pastures and cereal crops such as oats. Cultivation will invariably lead to a massive germination of mainly broad-leafed weeds, and depending on the weed present, at least one timely herbicide application should be routinely factored in.

A growth curve for fireweed was developed using the pasture systems model ECOMOD (Ian Johnson, personal communication, 2007) and long-term climate data (1901-2006) for Bega under a non-grazing scenario. Output from the model (t/ha) for the period 1$^{st}$ January 1907 to 31$^{st}$ December 2006 was summarised as daily averages over 1 year and graphed (Figure 17).

The main features of the simulated growth curve were that on average, germination occurs early, with growth commencing in late summer; although it needs to be confirmed experimentally, total dry matter yield in spring of about 1.4 t/ha seems reasonable based on visual estimates of single-species stands (based on experience with lucerne). Dry weight falls rapidly in late spring as the species flowers and senesces, and standing dead material persists through summer.

On the South Coast, fireweed germinates earlier than other annuals, such as subterranean clover; it rapidly elongates above the sward, thus enjoying a sunlight advantage; its early growth rate is higher than white clover, which does not contribute markedly to herbage mass until late winter; and its growth pattern is out-of-phase with summer-growing grasses, whose growth rates slow down from March onwards. Unpalatability of fireweed to cattle contributes to its success.

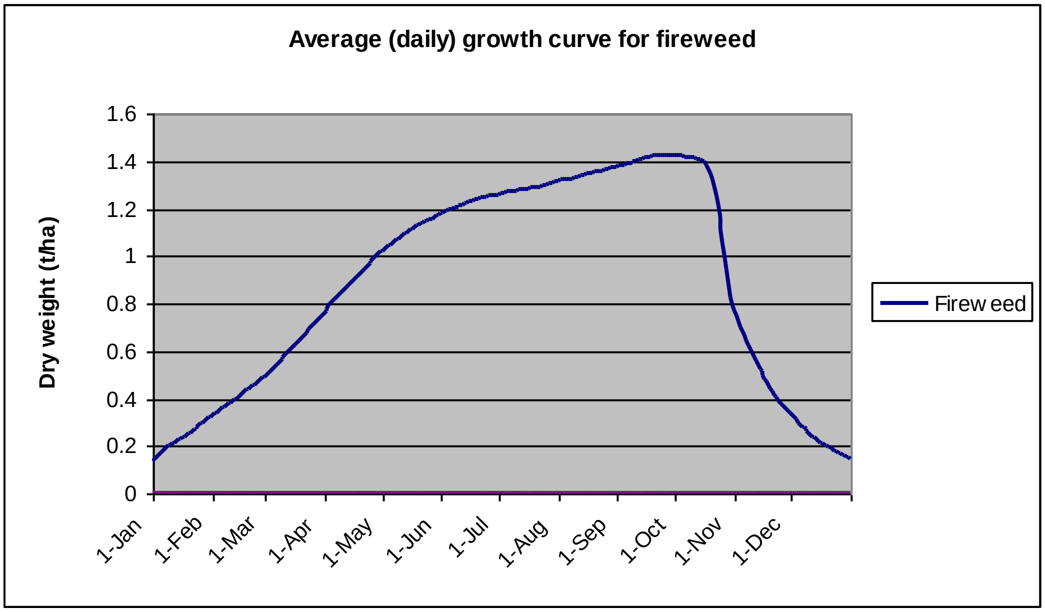


**Figure 17. Annual average growth curve for fireweed determined using ECOMOD**

Fireweed's growth 'window' seems not to significantly overlap that of other South Coast pasture species, thus it has a growth advantage, which is not necessarily competitive.

Fireweed's main weakness is that it is an annual whose persistence depends on producing copious quantities of highly viable seed in spring; and to establish from this seed the following autumn. Factors or actions that reduce these abilities *en-masse*, or interventions that specifically target them are more likely to reduce its long-term prevalence than non-targeted measures such as slashing, or occasional hand weeding.

### 4.3.2 Effect on animals

The specific effect of fireweed on animal health is unclear because of the difficulty of isolating fireweed toxicity from more prevalent animal health issues such as poor seasonal herbage quality; nutrient deficiencies including trace elements such as copper and selenium; intestinal parasites and liver fluke related liver damage.

The abattoir at Cooma processes mainly older classes of cattle and many of the livers of cattle sourced in Bega are rejected for human consumption. It is not possible to determine the extent to which fireweed is implicated because livers are not investigated determine their precise cause of rejection (Ian Lugton personal communication, 2007).

It is well documented that cattle and horses avoid consuming fireweed. In infested pastures, cattle become skilled at grazing around individual fireweed plants and they can be observed rejecting parts of plants they break off while grazing (Figure 18). The possibility that cattle cannot avoid consuming young fireweed plants hidden within the herbage mass is considered anecdotally to be a major risk, especially to young stock, but there is no data to support this concern.

**Figure 18. Cattle seem skilled at grazing around individual fireweed plants in pastures where there is sufficient preferred herbage.**

Available evidence suggests that the main circumstances under which cattle are exposed to a high risk of poisoning is when they are force-fed fireweed without choice (eg. the study by Kirkland *et al*. 1982); if they consume hay or silage that contains significant amounts (where they cannot exercise choice); or they graze pastures where there is virtually no available alternative herbage (i.e. their choice is limited).

(All evidence points to drought as a co-variable in instances of fireweed poisoning. For instance it was during the dry years from 1978 to 1983 that fireweed toxicity was noted in the Hunter and Bulahdelah districts of NSW (Walker and Kirkland 1981; Kirkland *et al*. 1982). It was also during dry years that serious incidents of PA poisoning in cattle, related to consumption of *S. pinnatifolius*, (which in this case probably was *S. pinnatifolius*), were recorded in central Queensland (Noble *et al*. 1994)).

(Data relating to the effect of ensilage on fireweed has not been discovered in the Australian literature. However, as a guide, silage containing more than 5% of a related PA containing species, Tansey ragwort (*Senecio jacobaea*), which is widely distributed in mainland USA, is considered unsafe for cattle or horses).

On the South Coast, during 2006, which was the 6th driest year on record, 6 of 31 Hereford cows with calves at foot were suspected of dying from fireweed toxicity (Anon. 2006). SCRLPB reported an additional 2 cases of suspected fireweed toxicity. In one case, 4 out of 10 cattle died; in the other, 18 died out of 50  (Ian Lugton personal communication, 2007). Given that there are some 60,000 cattle in the Bega Valley, these statistics point to isolated cases, possibly of poor management (overgrazing), rather than the existence of a significant or widespread fireweed-related animal health problem.

However, this issue is not closed. There is a lack of evidence both in respect of cattle mortality statistics (which are generally under-reported), as well as histological data. Thus firm conclusions cannot be drawn. This is an area that could be clarified by additional studies.

## 4.4 Pyrrolizidene alkaloids and fireweed

It has been confirmed, mainly from post mortem and dietary studies, that fireweed is one of many native and introduced plants that contain bitter-tasting Pyrrolizidine alkaloids (PA's) that deter predation from insects, pathogens and/or grazing. When these plants are consumed in excessive or consistent quantities by animals that cannot detoxify them, they can cause illness or death.

Many species of the daisy family (including *Senecio* spp.) contain these substances, as well as weeds such as: common and blue heliotrope (*Heliotropium europaeum* and *H. amplexicaule* respectively), and species of *Echium* spp (Patterson's curse, viper's and Italian bugloss).

(A review of data relating to PA poisoning of sheep in NSW (Seaman 1987), found that Patterson's curse and common heliotrope were the species that were mostly implicated, and that diagnosis of their impact was more evidenced as chronic copper poisoning than poisoning due to pyrrolizidine alkaloids).

(In some temperate grasses and clovers, such as tall fescue (*Festuca arundinaceae*), ryegrass and red clover (*T. pratense*), symbiotic endophytes and pathogenic fungi produce PA toxins. Under some conditions, these can also cause toxicosis in grazing or fed animals).

Worldwide some 6000 species (3% of the world's flowering plants) contain PA's.

According to the International Program on Chemical Safety (IPCS) (WHO 1988), PA's include more than 160 identified compounds.

There have been reports of human mortality linked to the accidental and deliberate consumption of PA containing plants. This has led to a number of authoritive reviews, focussing on PA's generally, as well as their potential impact on human and animal health.

Reports that were reviewed in the preparation of this section included: the Australian and New Zealand Food Authority (2001) (http://www.foodstandards.gov.au/_srcfiles/TR2.pdf); The International Program on Chemical Safety (IPCS) (World Health Organisation 1988) (http://www.inchem.org/documents/ehc/ehc/ehc080.htm)).

The IPCS review was the most detailed and authoritive as it presented a global perspective. The US Food and Drug Administration and the Ministry of Agriculture, Fisheries and Food (UK) have also published reviews relating to PA's and their potential impact on human health. These can be searched for on the internet.

Readers of this report wishing to know more than the brief points made here are advised to refer to these publications.

Following are some brief dot-points relating to PA's that are pertinent to the debate regarding risks to animal and human health posed by fireweed:

- It is clearly stated in IPCS (1988) that: "The toxic effects of pyrrolizidine alkaloids are mediated through their toxic metabolites and not by the alkaloids themselves."

  PA's in their N-oxide form, which is the form that occurs in plants, are chemically un-reactive and non-toxic. However, once ingested they are converted into free alkaloids, which are readily absorbed from the digestive tract. From here they pass to the liver, where they are metabolised into toxic substances (pyrroles). Pyrrolic metabolites bind to nucleophiles in the liver cells and mediate much of their cellular injury through damage to DNA.

- Damage may be the consequence of either or both, long-term low-level exposure to PA intake (chronic) or sudden large-dosage intake (acute).
- No regeneration or repair of liver damage has been recorded in livestock, but repair is known to occur in a proportion of affected humans.

### 4.4.1 Risks to human health

- Instances of human poisoning that have been directly linked to the consumption of PA-containing plants have been due to deliberate ingestion of PA-containing natural or herbal remedies (including beverages); the consumption of PA-containing plants as food (eg salads prepared using comfrey); or the contamination of staple food crops with seeds of PA-containing plants (most instances relate to seed of species of *Heliotropium*).
- Common heliotrope has been specifically implicated in Uzbekistan (former USSR). Other counties that have experienced endemic PA-related disease due contamination of food crops have included Afghanistan, India, the West Indies and Mexico. Cases of toxicity in United Kingdom, USA, Hong Kong and Ecuador have been linked to consumption of herbal medicine.
- No instances have been reported of human poisoning resulting from consumption of meat, milk, or honey. In the case of milk and honey, pre-market bulking and mixing of products from different sources reduces detectible PA concentrations.
- The risk consumption by humans and livestock, as well as crop contamination, has been consistently noted as being highest in arid-zone climates, and during or following periods of drought.
- Evidence of PA's being absorbed through skin at concentrations likely to cause harm is lacking.
- IPCS considered that provided that it was recognised, PA poisoning in humans, was entirely preventable.
- In Australia, comfrey, which world-wide has been documented as a major source of human PA poisoning, including any part of the dried plant and its extracts or preparations, is a scheduled poison, and is not available for sale for medicinal purposes.

### 4.4.2 Risk to livestock

- There is no evidence that PA's themselves accumulate in animal tissue, however, for susceptible stock, the tissue damage in the liver that results from their metabolism is cumulative and progressive, even at low rates of intake.
- PA's may be secreted in milk of cattle, sheep and goats but for animals grazing pasture, there is no evidence that the concentrations are sufficient to cause harm.

  (Studies reporting significant PA concentrations in milk involved experiments where PA-containing species were fed either exclusively or at high (often deliberately lethal) concentrations. Results could not be considered indicative of PA levels that may occur under non-force fed conditions).

- According to Hooper (1978), based on data relating to *S. jacobea*, the approximate ratios of quantities of plant material required to poison various species of animals (in order of increasing susceptibility) are: sheep and goats (200), mice (150), rats (50), cattle and horses (14), poultry (5) and pigs (1).
- Sheep (and presumably goats) owe their resistance to PA poisoning to high levels of metabolism (breakdown) of PA's by rumen microorganisms, coupled with hepatic (liver) enzymes, which may provide pathways whereby absorbed PA's are less likely to be converted to active metabolites.
- As a cautionary point, there is some indication from the literature of an interaction between species containing PA's and their effect on different livestock species. Thus literature relating to a particular species of plant or animal may not reflect the risk or response for a particular animal species grazing a particular PA-containing plant.
- PA's are believed to be biodegradable, so they are not persistent in water supplies.
- Within the various reviews, the risk (or occurrence) of PA poisoning has been consistently linked to drought or aridity. This implies that grazing animals (and indeed, humans) avoid PA containing plants, until alternative forage is virtually exhausted.

As graziers would observe, livestock faced with starvation, will consume the most unpalatable and un-nutritious forage until there is virtually nothing left. For most herbivores, PA-containing plants lie near the bottom of the preference scale. This is why there is a strong link, through the literature, between animal (and human) mortality, and drought.

### 4.4.3 Pyrrolizidine alkaloids and *S. madagascariensis*

There is a tendency throughout the 'soft' fireweed literature to draw conclusions, or make predictions based on research involving a wider range of PA-containing species aside from *S. madagascariensis* (in particular *S. jacobea*, and species of *Heliotropium* and *Echium*).

However, it is clear from specific literature that the concentrations and PA compounds present are species-specific (Table 7). It follows that the danger posed to livestock by different species may also be different, which raises the question: just how toxic is *S. madagascariensis* and what level of danger does it really pose?

The total alkaloid content of *S. jacobea* used by Hooper (1978) as a basis for animal tolerance calculations was 2700 ppm. This is 9 times higher than levels reported for *S. madagascariensis* from the Hunter Valley by Walker and Kirkland (1981) (300 ppm).

**In a study undertaken in Hawaii Thorne *et al*. (2005) identified 10 PA's in *S. madagascariensis* (**

Table 8). Contrary to previous studies that nominated Senecionine as the most prevalent fireweed PA (Sindel (1989), these Authors reported that Otosenine and Florosenine occurred with highest concentrations.

**Table 7. An incomplete list of PA-containing species, together with the diseases they have been associated with, and their specific PA compounds. (IPCS (WHO, 1988); Gardner *et al*. 2006)**

| Species | Common name | Disease | Constituent alkaloid |
|---|---|---|---|
| *Arnsinckia menziesii* | Yellow-burr weed (temperate Australia; inc. Wimmera | Not specifically implicated | Intermedine; lycopsamine; 7-acetyllycopsaminet |
| *A. intermedia* | Fiddleneck | Walking disease of horses; hard-liver disease in cattle & pigs (in Canada). Occurs also in Australia | Echumine; intermedine; lycopsamine; sincamidine; + an incompletely characterized alkaloid |
| *Crotalaria retusa* | Wedgeleaf Rattlepod (Naturalised in tropical-subtropical Australia) | Kimberley Horse Disease | Monocrotaline and retronecine N-oxide; retusine; retusamine; and an incompletely characterized base |
| *Echium plantagineum* | Salvation Jane/Pattersons curse | Liver failure | Echiumine; echimidine. |
| *Echium vulgare* | Vipers bugloss | Liver failure | Heliosupine; asperumine; echinatine; |
| *Heliotropium europaeum* | Common heliotrope | Toxaemic jaundice or 'yellows' (sheep) | Heliotrine and lasiocarpine |
| *Heliotropium lasiocarpum* | (Does not occur in Australia) | Human deaths due to contaminated grain (USSR)<br>(Also used as herbal tea) | Heliotrine and lasiocarpine |
| *Indigofera linnaei* | Birdsville indigo | Toxic to horses; does not affect cattle. | Indospicine |
| *S. pinnatifolius* | Variable groundsell | Liver failure | Senecionine |
| *S. madagascarien sis* | Fireweed | Liver failure | Senecivernine, senecionine, integerrimine, senkirkine, mucronatinine, retrorsine, usaramine, otosenine, acetylsenkirkine, desacetyldoronine, florosenine, doronine |
| *S. jacobaea* | Tansy ragwort (naturalised widely in USA & Europe). Occurs in temperate Australia. | Liver failure | Jacobine, jaconine, jacozine, otosenine, retrorsine, seneciphylline, senecionine, and senkirkine |
| *Swainsonia* spp.<br>(Mainly *S. canescenes*) | Darling pea or poison pea (cattle and horses become addicted to the plant; mainly in Australia's arid zones) | Swainsonia poisoning in horses and cattle | Swainsonine (a indolizidine alkaloid poison) |

**Table 8. Range and concentrations (parts per million of dry plant matter) of Pyrrolizidine alkaloids in *M. madagascariensis* collected from 5 elevations on the island of Hawaii (data from Thorne *et al*. 2005).**

| | Elevation (m) | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Average | Relative importance |
| Alkaloid | 762 | 944 | 1066 | 1219 | 1950 | PA conc. | (%) |
| Senecivernine | 5 | 14 | 29 | 43 | 53 | 28.8 | 3.1 |
| Senecionine | 9 | 14 | 19 | 32 | 15 | 17.8 | 1.9 |
| Integerrimine | 6 | 7 | 7 | 11 | 10 | 8.2 | 0.9 |
| Retrorsine | 2 | 43 | 31 | 56 | 31 | 32.6 | 3.5 |
| Usaramine | 96 | 70 | 54 | 115 | 46 | 76.2 | 8.2 |
| Unknown | 4 | 16 | 3 | 21 | 4 | 9.6 | 1.0 |
| Otosenine | 36 | 429 | 264 | 678 | 71 | 295.6 | 32.0 |
| Desacetyldoromine | 24 | 38 | 117 | 55 | 92 | 65.2 | 7.1 |
| Florosenine | 193 | 121 | 679 | 167 | 153 | 262.6 | 28.4 |
| Doronine | 60 | 76 | 306 | 75 | 123 | 128 | 13.8 |
| Total PA concentration | 435 | 828 | 1509 | 1253 | 598 | 924.6 | |

**While total PA concentration ranged from 436 to 1508 ppm across the Hawaiian samples (**

Table 8), the range across a parallel group of samples from the island of Maui was 217 to 1990 ppm. Although the Authors offered no explanation for the differences, considering the overall data (Walker and Kirkland 1981; Thorne *et al*. 2005 and Gardner *et al*. 2006), it is likely that the 'average' PA concentration in *S. madagascariensis* lies in the lower to middle ranges of these values (300-800 ppm).

Thorne *et al*. (2005) noted that the PA concentrations in *S. madagascariensis* were considerably less than lethal concentrations reported in other studies for *S. riddellii* and *S. jacobaea*, which have ranged from 2,000 to 45,000 ppm.

From these data, it seems that the risk of acute fireweed poisoning is probably low. Poisoning probably will not occur except under conditions when fireweed is the only herbage on offer, which, from an animal welfare perspective is a poor management outcome. On the other-hand, exposure to chronic fireweed poisoning may be more prevalent than currently believed; the evidence of this is difficult to determine, while the economic ramifications are compounded with a number of other issues.

It is believed that PA's in *Senecio* are produced in the roots, and that the only role of these bitter-tasting secondary metabolites is to protect the plant from predation. According to notes from the Canadian Poisonous Plants Information System (http://www.cbif.gc.ca/pls/pp/poison), flowers of *S. jacobaea* and *S. vulgaris* contain the highest concentrations of PA's, and that concentration in leaves increases to a maximum just before flower maturity. The same could be the case for fireweed, but there seems to be no direct evidence of this.

### 4.4.4 Grazing management implications

Evidence suggests that where the total grazing pressure (the sum of the grazing pressure of domestic and native animals) is within the capacity of the pasture to allow choice, horses and cattle in particular, will avoid PA containing plants. Sheep and goats find some PA-containing species particularly unpalatable (but faced with starvation they will graze them (eg. heliotrope and Patterson's curse), on the other hand, they are known to selectively graze other PA-containing species including fireweed.

Cattle experience limiting feed availability at herbage levels of about 700 kg available dry matter/ha (kg.DM/ha). Sheep and goats can access forage at levels of 300 kg.DM/ha. In pastures containing fireweed, as feed on offer approaches and falls below these levels, the risk of poisoning probably increases dramatically.

Risks are highest when normal stocking rates are maintained during drought, or seasons of normally limiting feed availability, and PA containing plants make up a high proportion of the available herbage, or are actively growing.

In Coastal Districts, risk of poisoning from fireweed in spring and summer is greatest in dry years. Because of low pasture growth rates in winter the risk may be more generally higher. In inland districts, where heliotrope and Patterson's curse (and related species) may be implicated, risk is highest in summer (particularly for heliotrope, which is a summer-growing $C_4$ species).

If the palatability of fireweed is increased by herbicide application (Bromoxynil) or slashing late in the season (flowering and post flowering), the risk of consumption increases. (Slashing also mixes the herbage making it difficult for animals to avoid consuming fireweed).

Two other conditions under which PA containing plants may be consumed at higher levels are:

- When stock are fed rations (hay or silage) containing more than 5% PA plants (a nominal level given in US literature for hay contaminated by *S. jacobea*).

- When paddocks containing PA plants are 'crash grazed' by animals not used to PA plant exposure.

(When large numbers of animals are grazed together, competition for the available forage overrides the usual palatability hierarchy in the mix of plants present. This situation arises more typically in cropping situations, where for example, stubbles containing heliotrope or standover remnants of Patterson's curse are grazed very heavily before being prepared for sowing. It can also arise when large numbers of cattle are held in confined areas such as yards, or night paddocks along travelling stock reserves).

## 4.5 Options for reducing the prevalence of fireweed

Cattle-based enterprises dominate agricultural output in the Bega Valley, thus most landholders judge the effectiveness of control in terms of its actual or perceived impact on the numbers of cattle they carry (stocking rate); the health of their cattle; and its possible impact on their products (milk or beef).

For some landholders, of equal (or even primary importance), is the impact of fireweed on the appearance of their landholdings.

Choice and perceptions of risk are factors in implementing control strategies. Some landholders simply choose to ignore fireweed; others don't see value in undertaking control, especially when it has been their experience, or those of their neighbours or friends, that techniques are difficult or complicated to implement; they don't work; they are expensive (low benefit relative to cost); or they are philosophically at odds with their enterprise or lifestyle focus (for instance, organic agriculturalists). Some landholders reported they were deterred from using herbicides because exposure made them feel unwell.

Other factors also impact on the willingness or capacity of landholders to take action. For instance, the growing number of absentee landholders in the Valley, and the 'weekend-farmers' may not be well placed to implement control measures that require constant monitoring or management; owners of small-holdings may not have animals at all and so on.

For control techniques to be widely applied across this broad spectrum, they must be robust; demonstrably successful; lead to some perceived or measurable benefit; and for optimal success, be accompanied by a learning/evaluation process.

Excluding biological control, which will be considered only briefly in this report, control of fireweed is limited to the use of 4 registered herbicides; and grazing by sheep and goats. Pasture professionals often state better pasture management as an effective approach, but during drought, when fireweed seems more prolific, landholders see little scope of approaching fireweed suppression from this perspective.

### 4.5.1 Herbicides for controlling fireweed

(Note: discussion of herbicides in this report does not constitute endorsement or expert opinion).

(Before contemplating the use of specific products, it is essential to read and follow all warnings, instructions and safety directions provided on product labels. NSW law also requires users of herbicides have in their possession materials safety data sheets for the products they store or use).

#### 4.5.1.1 Development and testing of herbicides for fireweed control

There have been no herbicides developed specifically for controlling fireweed. According to one Company representative, all registered herbicides used for broad-leaf weed control were developed primarily for use in broadacre cropping (cereals, maze, cotton etc). Herbicides used in pasture situations account for a very small proportion of the total market, and have generally been tested and registered for these purposes as a result of local and possibly less scientifically stringent evaluation. Testing has also sometimes been restricted to potential candidate products marketed by single companies.

There is a need to more broadly evaluate the range of herbicides that are available, within a demonstration context, and explore issues related to their efficacy such as, rate and time of spraying.

#### 4.5.1.2 Herbicides registered for fireweed

In addition to various brands of herbicides containing glyphosate, which is a non-selective, broad spectrum herbicide, most useful for preparing ground for pasture and crop sowing, there are several brand-named selective herbicide mixes, as well as several brands of straight bromoxynil herbicides registered for controlling fireweed in pasture and crop situations[1] (Table 9).

Retailers in the Bega Valley report that straight bromoxynil brands of herbicide account for the majority (>80%) of herbicide used against fireweed; that herbicide is applied mainly from late winter onwards; and that it has only been over the last 3 to 5 years, that significant volumes of herbicide have been applied.

#### 4.5.1.3 Herbicide effectiveness

Landholders report varying levels of success in using herbicides. In order of their relative importance, the main causes of unsatisfactory outcomes are:

- Failure to recognise the extent of the problem early enough, and spraying too late after a significant number of plants in the population have flowered.
- Spraying at a rate too low for the growth stage of the weed.
- Use of spray equipment that has not been recently calibrated.
- Lack of being able to track spray application while spraying (eg. using foam markers).

Evidence of an unsatisfactory outcome, is reported as incomplete kills; plants apparently dying, but re-sprouting and living another season; and rapid re-infestation of sprayed areas. (Some landholders perceive re-sprouting plants that might have been slashed or apparently killed, as seedling re-infestation. In some cases this leads to repeat spraying/slashing (which becomes less effective as the season progresses).

[1] A search of the Australian Pesticides and Veterinary Medicines Authority database (December 2008) listed a total of 40 brand-name chemicals registered for controlling fireweed. However, most of those (many containing Diquat/Paraquat) were only registered for use in cropping situations in northern Australia. It is vital to check the currency of labels and permits in considering herbicide suitability. (Note: The use of both Diquat and Paraquat in Australia is currently under review by APVMA).

**Table 9. Commonly used registered brand names of herbicides used to control fireweed in NSW, and their active ingredients.**

| Herbicide | Group | Active ingredient 1 | Active ingredient 2 | Comment |
|---|---|---|---|---|
| Bromoxynil 200 | C | 200g/l Bromoxynil | N/a | Several brand names |
| Hotshot | I | 10g/L Aminopyralid | 140 g/L Fluroxypyr | APVMA Permit PER10921. |
| Jaguar | C + F | 250 g/L Bromoxynil | 25 g/L Diflufenican | |
| Barracuda | C + F | 230 g/L Bromoxynil | 21 g/L Diflufenican | |
| Tigrex; Nugrex | F + I | 250g/L MCPA | 25 g/L Diflufenican | Suppression only |
| Giant | F + I | 230g/L MCPA | 21 g/L Diflufenican | Suppression only |
| Amicide 625 | I | 625 g/L 2,4-D | N/a | APVMA Permit PER10462 (Coffs Harbour City Council only). |

Anecdotally reported responses to herbicides are weed focussed, rather than production focussed and no experiments have been carried out to convincingly show one way or the other, that a productive benefit arises from their use.

A secondary issue relating to timing is that during optimal times for spraying, contractors are often overwhelmed by demand for their services. Weather conditions are also a factor.

#### 4.5.1.4 Factors affecting the success of controlling fireweed using herbicide

- The most important factor contributing to the success of using herbicides to control fireweed is time of spraying. (Several landholders ranked timing as accounting for >90% of the variation in relative 'success').

  In the North Coast Region of Coffs Harbour it is recognised that Bromoxynil is ineffective, even at the highest rate of 2.8 L/ha once flowers have appeared (Barry Powells, Personal Communication, 2007). Furthermore, Powells observed that when sprayed late (post-flowering), many older plants appear to be killed, but they often re-sprout. This is similar to the situation reported in the Bega Valley.

  It seems that there is a point in time, possibly, late July, when it is better to resist applying herbicide and wait until the following year.

- The most succinct recommendation is to spray 2 to 3 weeks after the first significant rainfall event that occurs after the end of February (Harry Kemp, personal communication, 2004) (Figure 19).

**Figure 19. A trial of the effectiveness of applying herbicide (Jaguar; applied at 500 ml/ha) near Bemboka. (130 mm of rain was received over 9 days at the beginning of March 2007; spraying was carried out about 20 days later (28 March); the photograph was taken on 24 September 2007). No fireweed plants were recorded in 20 randomly thrown 0.25m$^2$ quadrats in the sprayed area (foreground); average of counts in the unsprayed area was 18.2 plant/m$^2$.**

- The second most important factor is to use the most cost effective and bio-effective herbicide for the situation.

  The drum and application rate costs of the range of herbicides registered for Fireweed control (based on average single-drum prices quoted in Bega in August 2007) are given in Table 10.

It can be seen from Table 10, that although the drum price of Bromicide is less than other chemicals, its per hectare cost is considerably higher.

(Tigrex represents a special case, which will not be considered further. Although it is registered for fireweed control, according to its label, it has a suppressing effect only. It may therefore not be useful in situations where fireweed is the only target weed).

**Table 10. Cost and application rates of herbicides most commonly used for controlling fireweed in the Bega Valley. (Costs are based on average 20 L single-drum prices in Bega (August 2007).**

| | | Application rate @ growth stage (L/ha) (Ha/drum is given in parenthesis) | | | Herbicide cost ($/ha) | | |
|---|---|---|---|---|---|---|---|
| Herbicide | Av. cost ($/drum) | Seedling | Early flowering | Mature | Seedling | Early flowering | Mature |
| Bromicide | $327 | 1.4 (14.2) | 2.8 (7.1) | Not effective | $22.93 | $45.85 | N/a |
| Hotshot | $468 | 0.5 (40) | 0.5 (40) | 0.5 (40) | $11.70 | $11.70 | $11.70 |
| Jaguar | $564 | 0.5 (40) | Not recommended for older plants | | $14.10 | N/a | N/a |
| Tigrex | $495 | 1.0 (20) | Supression only | | $24.78 | N/a | N/a |

#### 4.5.1.5 The economics of controlling fireweed with herbicides

In the absence of data indicating that controlling fireweed using herbicides sustains or increases pasture production, and that this is reflected in the marketplace, the economics of herbicide use are difficult to determine.

The cost-side of the equation includes herbicide, the cost of machinery and its operation, and the cost of time. As a guide and depending on the ease of the job, the cost of contracted boom spraying in the district is between $80 and $110/hr ($20-$25/ha) + chemical.

Savings are possible through careful timing, and chemical cost, but these are small compared with the cost of labour, fuel and machinery, which cannot be avoided. Cost-efficiencies can also be gained by using accurately calibrated spray equipment and foam markers.

(There is an issue in calculating costs. Although contractor rates are usually used, in reality, the direct cost to a landholder only accrues when they write out a cheque. Landholders, who undertake herbicide work as a routine activity, do not pay themselves; and they rarely perceive a cost-offset in terms of other ‘more profitable’ activities they could be doing).

In addition to the impact on cost and effectiveness, spraying early reduces exposure of cattle to unavoidable intake of small plants obscured within the herbage mass.

#### 4.5.1.6 Why use herbicides?

If herbicides are not economic to use (that is, if they don’t result in a demonstrable increase in production or productivity, or a reduction in livestock mortality), then their use is questionable. However, if they assist in achieving control of fireweed that has become rampant over several years, so that other strategies for managing the problem can be put in place then they serve a dual purpose.

Herbicides should be seen as part of an overall plan, rather than a quick fix. The plan should focus on maintaining the balance in favour of the species that are useful and productive in the pasture, because it is these plants and this balance that will underpin the return on investment.

A second important role for herbicides is to insure that some ‘clean’ paddocks are available for grazing heavily in spring and early summer in the event that low rainfall conditions prevail.

#### 4.5.1.7 Using herbicides efficiently

A goal of totally ridding a landholding of fireweed (zero-tolerance) using herbicides is unrealistic. The impossibility of achieving the goal leads to frustration as well as expenditures well out of proportion to the threat posed by residual populations.

Experience indicates that herbicides should be used judiciously, and not more than once in a single year.

Several approaches can be used to assist deciding if herbicide use is warranted, and prioritising where they are best used, given that all herbicides will affect pasture growth somewhat, and that pastures need to be rested after spraying according to withholding periods given on product labels.

Approaches include:

- Deciding on a tolerable fireweed level (for example, 5 mature plants/m$^2$ during the previous spring; or 20% of estimated total prior-spring herbage mass), and only spraying areas where fireweed has built up above the level.

  (Prioritisation of paddocks to be treated needs to be planned when fireweed is flowering, in the year prior to treatment).

- Limiting herbicide use to a number of drums, or $/year.

  Using this approach, prioritisation of problems areas in the year prior to treatment may concentrate on treating paddocks; or ‘hot-spots’ within paddocks, or landscape ‘hot-spots’.

- A time-limited approach would involve planning around time-windows; and a prioritisation process similar to that above.

Using an aerial photograph or map of the landholding considerably assists the planning process.

(Using Lot and DP (deposited plan) numbers, it is possible to print useful aerial maps of properties in NSW via the Maps NSW website: http://www.maps.nsw.gov.au/six_viewer.html).

##### 4.5.1.7.1 When and where to use herbicides

While bromoxynil-based herbicides are most effective on seedlings in autumn and winter, the extent of a fireweed problem is usually observed when the first wave of plants flower in spring. Landholders that are alarmed by the apparent severity of their problem often apply herbicides at this time, which is too late to be effective and to prevent seed-set.

Late herbicide application diminishes the effectiveness of herbicide use in the following year because the high proportion of plants that re-grow are resistant to further applications. A further potentially very serious issue is the possibility that application to relatively tolerant older plants, may lead to bromoxynil resistance in the wider population.

Timely application of herbicide requires anticipation of the likely extent a problem, based on observations the previous spring and early summer. This could be a paddock-by-paddock decision. Where resources or time are an issue, a prioritised approach, where only high-density patches (hot-spots), within paddocks are targeted, may be more appropriate. For either approach, savings result from applying the most cost-effective herbicide at the lowest recommended rate, and applying it only once/year.

The effectiveness of single well-timed applications may last longer than 3 years.

Some of the benefits and drawbacks of the 3 main herbicides registered for fireweed control are given in Table 11. (Landholders contemplating the use of herbicides should draw their own conclusions from studying product information, regarding the comparative benefits of particular products for their situation).

**Table 11. A brief list of some of the benefits and drawbacks of the 3 main fireweed herbicides, based on product labels and anecdotal information.**

| Herbicide | Main benefits[1] | Main drawbacks[1] |
|---|---|---|
| Bromoxynil 200g.a.i/L | Higher rates recommended for plants at pre-flowering to early flowering. This may improve flexibility by extending the spraying 'window'. | Should not be used when temperatures exceed 20°C<br>Minimum of 160-200 L of water/ha recommended where weed infestation is heavy.<br>Will not prevent older plants setting viable seed. |
| Hotshot | Relatively inexpensive; can be used at all growth stages, including older (post-flowering) plants; 7-day grazing withholding period. | Withholding and stock feed restrictions apply for livestock destined for export markets (see label).<br>Spray and soil residue kills legumes. Active in the soil for extended periods (eg. 20 month recommended plant-back periods for lucerne and subterranean clover).<br>Residual effect may prevent establishment; effect on seed-set and viability not known. |
| Jaguar | Highly effective and relatively inexpensive at the seedling stage.<br>Residual weed control is a feature of Jaguar; but for fireweed, this has not been confirmed specifically. | Should not be used when temperatures exceed 20°C<br>Less effective as plants get older (flowering and post-flowering).<br>Minimum of 80 L water/ha recommended. |

[1] Refer to product labels and Material Safety Data Sheets for full details.

### 4.5.2 Use of sheep and goats to control fireweed

Sheep and goats are increasingly being used to control fireweed in the Bega Valley, but because they also compete directly with cattle for pasture, there is a direct DSE trade-off equivalent to about 8 DSE (1 DSE = 50 kg wether) to a growing steer (350kg yearling growing at 0.5 kg/day).

Stocking rates for goats are calculated on a pro-rata weight basis. A large 100kg buck, for instance has a DSE rating of 2 (100/50); while a sexually mature 30 kg doe has a DSE rating of 30/50 = 0.6.

While a proportion of the diet of goats consists of dry roughage and species that cattle don't graze, it is wise to assume that their forage requirements require a similar DSE offset as sheep.

In order to avoid overgrazing pastures, farm stocking rates must be maintained within safe margins. So for each 10 DSE's worth of 'weeders' introduced to a farm, cattle numbers need to be adjusted downwards by the equivalent of a 350 kg growing yearling.

(A brief web-based search will uncover considerable advisory information to assist in planning the inclusion of sheep or goats into existing farm enterprises. Assistance is also available from DPI offices in Cooma, Goulburn and Wagga Wagga).

In the face of the fireweed problem, there are numerous combinations of sheep and goat -based strategies being employed, some as serious alternative businesses.

For instance, a growing number of Bega Valley full-time small-area producers, have turned to fibre or meat-producing goats as their main enterprise; some also breed specialist or boutique pure-breed sheep, including meat-producing sheep, such as Dorpers.

Some cattle producers on larger holdings that have sheep or goats look on them as 'weeders'. They may run only wool-producing merino wethers, which they trade; or alternatively, a 'low-intensity' merino dam -based 1$^{st}$-cross lamb enterprise. Others, while still dominantly focussed on beef, have profitably expanded their enterprise mix by producing quality 2$^{nd}$ cross prime lambs, using 1$^{st}$-cross merino dams and quality rams.

In considering issues such as fly-strike, sheds for shearing and crutching, some cattle producers have embraced Dorper sheep as a low-care alternative to wool-producing breeds, assisted somewhat by several enthusiastic Dorper breeders.

So there is a range of possibilities actively being explored by Bega Valley landholders looking for ways to combat fireweed, which are enterprise-based, and profit-motivated.

Table 12.

It is the case, that in the Bega Valley, producers looking for a way forward with fireweed are not well supported institutionally. In NSW DPI today, there are no specialist goat officers; the closest sheep and wool officer to the Bega Valley is in Cooma, then Goulburn or Wagga Wagga. It is not within the capacity of the SCRLPB to provide an extension service, thus the level of expertise they can reasonably provide is limited.

Producers are thus left to undertake their own research and utilise their local networks to help them develop profitable strategies. (Some goat producers, in particular have developed extensive libraries of collected material, and they are linked through web-sites to exchange information and experiences).

Perhaps it is human nature, but producers who stoically resist turning to sheep or goats for controlling fireweed invariably emphasise down-side problems, such as fences, shearing sheds, yards, etc. Producers who have experimented with sheep and goats, and have developed them into a venture, emphasise the up-side of their journey. This principally involved low-cost approaches to solving problems. Use of electric fences; adapting existing yards; utilising disused dairies, garages, and machinery sheds temporarily as shearing or kiding facilities and so on. It is a barrier to adoption that ‘make-do’ approaches are not overly emphasised in extension material.

**Table 12. Advantages, disadvantages and risks associated with sheep and goat based enterprises that may be conducted at a commercial scale for fireweed control in the Bega Valley.**

| | Advantages | Disadvantages | Risks |
|---|---|---|---|
| Merino wethers | Flexibility.<br>Good weed controllers.<br>Can be pushed hard to eat poor quality pasture.<br>Easy management – no reproduction. | Shearing and handling facilities required.<br>Not highly profitable – needs to be run as ‘low-input’.<br>Increased damage to pastures from trampling, camping and nutrient transfers.<br>Cost and time taken in crutching and shearing.<br>Minimum economic number is 100-200 head. | Only wool to be sold.<br>Difficulty getting shearers. |
| Merino dams; terminal sire; 1st cross lambs. | Profitable.<br>Meat and wool to sell.<br>Easy and relatively cheap to buy. | Shearing and handling facilities required.<br>Cost and time taken in crutching and shearing.<br>Lower fertility.<br>Poorer growth rates. | Purchase of other people’s cull sheep. |
| Self-replacing 1st cross ewes; 2nd cross lambs | Fertile – lots of lambs.<br>Meat and wool to sell.<br>Easier management than Merino ewes. | Shearing and handling facilities required.<br>Expensive to buy.<br>Tough on fences.<br>Cost and time taken in crutching and shearing. | Availability might become an issue. |
| Dorper ewes & lambs. | Quite fertile.<br>No shearing or crutching or flystrike. | Limited availability of ewes.<br>Expensive at present.<br>Tough on fences. | Only meat to be sold. |
| Boer goats | No shearing or crutching or flystrike.<br>Good weed controllers.<br>Breeder potential if livestock demand increases. | Killing abattoirs limited (Currently processed at Young, Cootamundra and Wodonga).<br>Expensive to buy in.<br>Don’t do as well in high rainfall areas.<br>Parasite prone.<br>Tough on fences. | Mainly meat to be sold. |
| Cashmere goats | Good weed controllers. | Shearing and handling facilities required.<br>Limited profit.<br>Don’t do as well in high rainfall areas.<br>Parasite and footrot prone.<br>Do not grow fast.<br>Tough on fences.<br>New skills to learn in breeding and management.<br>Cost and time taken in crutching and shearing. | Specialised market for cashmere. |
| Angora goats | Good weed controllers. | Same as for Cashmere production | Specialised market for mohair. |

A common disadvantage to all combinations of sheep and goat –based enterprises is that, except for on-farm sales, the closest market for selling or buying stock is Cooma for sheep, and Wodonga or Camden for goats. Goat enterprises also suffer a problem of scale. Because individual enterprises are conducted at a small scale, car-trailer loads rather than truckloads of animals are exported from the district for sale or slaughter. This could be overcome by more efficient net-working and market-targeting; for example goat markets are generally strong at Camden at the end of Ramadan (which occurs usually in spring).

#### 4.5.2.1 Effect of fireweed on sheep and goats

Despite extensive searches, no information relating to the specific effects of fireweed on the health of sheep and goats was located. There were also no reports of death of sheep or goats A lot of general PA related information could be cited, but it is based on observations or research conducted with other species. Data from Australian studies is biased towards the impact of Patterson's curse and heliotrope PA's on sheep; there is little Australian information relating to goats.

Landholders that were interviewed for this project had not observed that fireweed unduly affected the health of their sheep or goats despite in some cases, the animals being exposed to seasonally high fireweed intake for periods of up to 5 or 6 years. For both animal species, if high mortality was experienced, it was invariably due to barbers-pole worm or blowfly strike; no producers recounted instances of when they suspected mortalities were due to grazing fireweed; and some producers who had slaughtered their own stock for consumption did not recall signs of unhealthy livers or other organs.

So producers who are concerned about the possible health impacts of fireweed on sheep and goats need to rely on either un-proved anecdotal evidence or scientific data that does not relate to their particular weed.

Toxicity of fireweed is a serious concern, which has significant management and marketing implications and there is a pressing need for studies in this area.

#### 4.5.2.2 Management strategies for sheep and goats

Landholders using sheep and goats reported developing their own management strategies, which to some extent, depended on the management needs of their main cattle-based enterprises.

It was reported that when fireweed was flowering, goats preferentially grazed flower heads; at other times they targeted young, growing shoots. Goats also grazed dead, woody residue during summer. Because goats preferred roughage to freshly growing pasture, they were not seen as competitors with cattle for the same pasture. Flocks of goats were thus generally used to clean-up fireweed infested paddocks before cattle grazed them. They could also be run concurrently with cattle.

Landholders with appreciable numbers of sheep tended to either set-stock them or they used a long-rotation form of grazing management, sometimes to keep some fresh paddocks for lambing or other purposes. The management and forage-quality needs of higher-input sheep enterprises, such as prime lambs, lessened their role as 'weeders' especially in spring. Nevertheless, they still had a big impact on farm-scale fireweed populations, which resulted in producers being generally optimistic about profitably dealing with their fireweed problem.

Landholders who used sheep specifically as 'weeders' usually used merino wethers. If they were not used to grazing fireweed, newly purchased sheep were sometimes acclimatised by leaving them in a grazed-out pasture with mainly fireweed on offer. Sheep then followed cattle as they were rotationally grazed. One landholder described a 'leave-behind strategy'. In this case, he used large numbers of wethers to graze fireweed after cattle, but when he moved them on to the next rotation sequence, he left a small number behind to continue putting pressure on re-growing fireweed. He claimed that this strategy was effective in preventing further flowering of fireweed as plants recovered.

Cattle introduced onto fresh pasture avoid grazing fireweed. Sheep grazing after cattle find their dietary choice considerably reduced.

#### 4.5.2.3 Effectiveness of sheep and goats

Throughout the Bega Valley and elsewhere, pastures grazed by sheep or goats contain few fireweed plants, especially flowering plants. Pastures grazed by goats are cleaner also of other woody weeds, such as blackberry, blackthorn, briar, paddy's lucerne and a range of thistles. No evidence has been noted of camping effects resulting from goat grazing; however, long-duration grazing by sheep, leads to development of sheep-camps and other potentially undesirable outcomes.

As a cautionary note, sheep and goats do not get rid of fireweed. It is the Author' s experience, that when sheep were removed from a newly purchased property, which was returned to a beef-only enterprise, fireweed returned rapidly. Use of sheep and goats needs to be seen as a long-term consistent strategy.

Goats are generally more work than sheep, but in some respects they are easier to train and handle. Goats require greater supervision; they are handled more often; they need to be protected to a greater extent from foxes, dogs etc. and during kiding, they are usually sheltered in a shed at night. They are also more vulnerable to inclement weather.

Sheep are more adapted climatically; more protective of their young; they can be left alone for longer periods of time; and there is a wider range of products available and registered to deal with internal and external parasites. They are also more readily marketed than goats. Wool produced the Bega Valley is also reputed to contain little vegetable fault.

#### 4.5.2.4 Barriers to adoption

Although the Bega Valley has a long history of sheep and wool production, there existed a perceptible cultural divide between dairy and beef only producers, and mixed enterprise landholders.

In preparing this work, it seemed that landholders with little historical or family association with sheep, found it a difficult to envisage using sheep for managing fireweed. (As evidenced by the lack of facilities for handling sheep (or goats) across the Valley, this applied to the majority of landholders).

A major barrier to developing alternative approaches to fireweed seemed to be a lack of institutional support, or alternative forums to help people 'get started'.

A second noticeable response within groups of landholders attending, for instance a field day or seminar, is that approaches can be rejected outright on the basis of just one issue. For example at a meeting of >100 landholders, someone asked about the cost of a shearing shed. After the cost of a new fully featured shed was given, many lost interest in the idea.

However, there are many inexpensive make-do sheds around; it is the design principles that are important, the things that make a shed work, and it is these that need to be promulgated. A book or pamphlet that explored these principles, illustrated using make-do approaches would be very handy for producers contemplating running a small mob of sheep for fireweed control.

All enterprises require investment, acquisition of knowledge and skills and incur risk. Several former beef-only producers became confident of including sheep in their enterprise mix through their friendship or neighbour network. Others, particularly those involved in new breeds such as Dorpers undertook extensive research and invested considerable sums to set up their enterprises. Despite having taken several years for landholders to get new enterprises set up and running at the scale they wanted, once in operation, they become a routine activity.

In some respects, goats require more specialist knowledge. This was balanced by a seemingly stronger internet-linked network of goat producers. Goats are an attractive option for people with small landholdings. Thus, although they can be serious enterprise in their own right, goats are often seen to be somewhat of a ‘hobby.

## 4.6 Business opportunities

Although fireweed is seen in the district as an overwhelming problem, within the matrix of ‘the problem’ business opportunities could be envisioned that provide mutual and multiple benefits to both traditional producers, and the growing influx of new people coming to the district (**Table 13**).

**Table 13. A non-exhaustive list of potential business opportunities that could be realised in response to fireweed in the Bega Valley.**

| Business vision | Client/Consumer | Beneficial outcome - Client | Beneficial outcome - Provider |
|---|---|---|---|
| Agistment specifically for fireweed control | Small area and absentee landholders, possibly with low levels of skill and experience. | Experience and increased skill through participation.<br>Minimal investment.<br>Community contact and networking. | Up-scaling opportunities.<br>Better utilisation of investment in facilities. |
| Increasing the pool of accredited, technically competent spraying contractors. | Small and large scale producers. | Herbicide applied on time, within budget; offset against own time & tied-up capital.<br>(‘A job well-done is worth twice the job!’) | Off-farm income opportunity.<br>Income from capital invested in equipment that may be underutilised.<br>Flexibility presented by dealing with a range of seasonal weed problems. |
| Speciality marketing of sheep and goat meat (eg. ‘Green as the Bega Valley’ brand). | All producers; possibly through a cooperative or other arrangement; focus is quality assured, based on best (on-farm) practice; target market share rather than premium market. | Market-driven approach to best-practice, product consistency and supply reliability. | Multiple supply-chain benefits.<br>Expansion of marketing arrangements. |
| Practical information brokering, networking or mentoring. | People faced with change or looking for new opportunities.<br>People seeking lifestyle change or retirement. | Networking and breaking down of information barriers especially relating to ‘hands-on’ or practical skill. | Networking; passing on experiences; learning new skills; being valued in the community. |

## 4.7 Fireweed and its biological control

In the Bega Valley, biological control of fireweed (release of host-specific natural enemies, which may be pathogens, parasites or consumers) is often seen as the ‘magic bullet’ solution to its prevalence. However, biological control is a complex issue, especially considering that fireweed is closely related ecologically and taxonomically to a large and complex group of important indigenous *Senecio* species that occur throughout Australia.

The most often quoted ‘successful’ biological control programs (those for prickly pear, rabbits and skeleton weed) involved species that were unrelated to any Australian native species. Although some risks were involved, these programs were relatively straightforward. The most spectacular failure of biological control programs, that of the introduction of cane toads and Indian myner birds to control sugar cane beetles, are also often quoted to highlight the need for caution and rigor in evaluating the potential impact of biological control strategies.

However, there are an overwhelming number of examples between success and failure, where results have been moderate to minimal in terms of impact.

Despite Australia's enviable record of plant, animal (and indeed human) quarantine procedures, disasters can still occur. The horse-flu epidemic is a case in point. An epidemic of similar proportions that affected a group of important indigenous pioneer species, such as *Senecio*, could be equally disastrous.

The following dot-point summary was collated from Morin (2003), which was commissioned by Shoalhaven and several South Coast Shire Councils; as well as concepts presented in Thomas and Reid (2007). Discussions were also held directly with Louise Morin, whose frank input is greatly acknowledged.

### 4.7.1 About biological control, herbicides, sheep and goats and fireweed

Fireweed is essentially an agricultural weed. It responds to conditions associated with agriculture, such as elevated soil fertility; low ground cover in autumn and winter and lack of competition from naturalised or sown species during its establishment. Cattle avoid grazing fireweed, which assists its dominance, and promotes its reproduction. Where it is grazed by sheep and goats, which are resistant or tolerant of the effects of PA intake, fireweed does not dominate. Although its reproductive potential is considerably reduced, herbivory does not eliminate the weed.

Applying the nomenclature and concepts outlined by Thomas and Reid (2007), fireweed seems to behave according to the 'passenger' invader model; that is, invaded communities (pastures) are primarily influenced by external or environmental factors, which do not constrain the invader (fireweed) to the same extent as they do the 'desirable' species. Thus its dominance during drought; and its invasiveness into pastures that are somewhat dormant from autumn to spring.

Effective biological control aims to suppress the target to a level where it no longer poses a significant problem. However, for a free-seeding annual species such as fireweed, there is little evidence that reductions in plant performance would greatly reduce weed abundance. There were also few instances found where an annual species has been successfully controlled by biological control agents. (Although seemingly successful, the longer-term efficacy of some current programs (eg. Patterson's' curse) have yet to be fully assessed).

In the Bega Valley, pasture production and the apparent success of fireweed are linked inversely to rainfall. There is therefore little prospect that suppression of fireweed alone would lead to increased agricultural yield.

(Irrigated pastures represent a special case. They may be used to produce high-value hay or silage, or they are stocked with large numbers of cattle relatively briefly. In both cases, it is both economic and desirable to routinely remove fireweed using herbicides or follow-on grazing by sheep or goats).

Applying a similar threshold concept to that used by Thomas and Reid (2007) (illustrated in their case by wild radish (*Raphanus raphanistrum*) and Pattersons curse), the impact density function for fireweed is suspected to be context dependent (Figure 20).

Low tolerance of fireweed even at low densities is a feature of high-input, high-output systems, typically irrigated dairy or hay-silage pastures, and crops. In these situations, compared with the overall cost of sowing, managing and maintaining the system, judicious and timely use of herbicides would be cost-effective, and could be economically justified. For these systems, based on considerations in Thomas and Reid (2007), there is little prospect that biological control would reduce weed densities below thresholds believed to cause harm.

Abundance levels that can be tolerated in dryland pastures grazed by cattle are higher, mainly because at usual paddock stocking rates, it is not grazed. Under a 'normal' climate scenario, the use of expensive inputs to control a weed, which does not impact greatly on production, is probably not justified.

However, if effective stocking rates (stocking rate per unit of available herbage) increases, for instance because of drought or low pasture growth rates in winter, thresholds may be lower. In this case a net benefit may arise through timely use of herbicide, but only if livestock mortality is avoided. If the use of herbicide does not reduce mortality, reducing stocking rates, or substituting sheep or goats in place of a proportion of the number of cattle carried may be the more viable option.

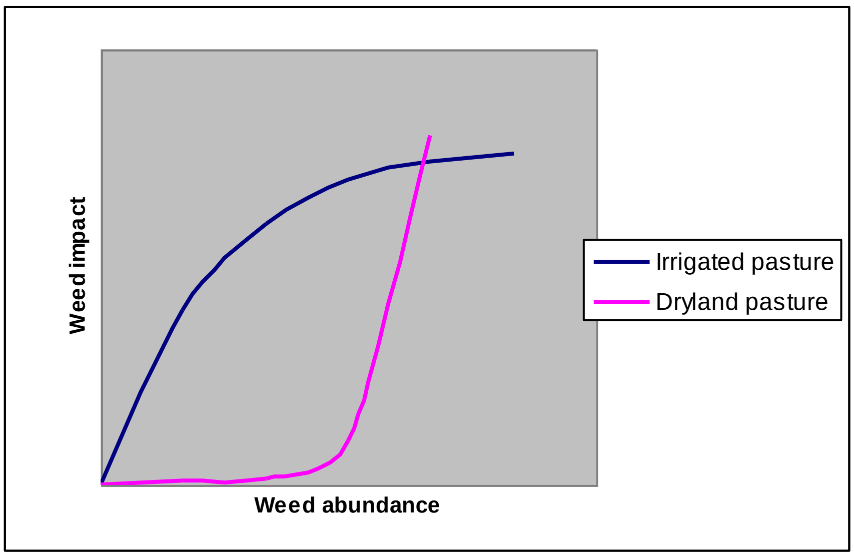


**Figure 20. Conceptual impact-abundance curves for fireweed under irrigated or dryland conditions (after Thomas and Reid (2007)).**

### 4.7.2 About biological control of fireweed

In Australia, importation, testing and release of biological control agents is governed by a number of protocols, which aim to protect Australia's biodiversity, and minimise the risk of the accidental or purposeful release of damaging organisms.

The underlying assumption to the protocol is that biological agents have the same potential as their targets to endanger production systems, people and ecosystems. Uncontrolled testing and release of organisms paves the way for biological control agents to become pests in their own right. Effects may be direct, where an organism attacks a range of non-target species; or indirect, where an organism disrupts populations of other organisms, which are important to other hosts.

The potentially re-bounding impact of a process that on the surface seems relatively simple is the subject of considerable debate and investigation (eg. Pearson and Callaway, 2005).

(For more details concerning protocols see: http://www.daff.gov.au/ba/about/plant/protocol-biological)

According to Harden (1993), the NSW flora contains >50 and possibly up to 70 species of *Senecio* (some are un-named). Many non-host specific insects, fungi and other organisms that are hosted by these species also attack fireweed. (A case of biological control in reverse, or biological defence).

Sindel *et al*. (1998) noted that Australian fireweed populations are attacked by up to 100 species of insects, including a leaf-feeding beetle and two leaf-feeding moths; seedhead feeding bugs; a leaf-stem borer, which is frequently observed ring-barking stems and attacking roots; a leaf-mining fly; and 2 species of gall-forming flies.

A rust that is native to Australia and New Zealand (*Puccinia lagenophorae*) may cause considerable damage to field populations of fireweed; and fireweed may also be infected by a grey mould fungus and a white rust.

The obstacle to the efficacy of existing agents seems to be fireweed's ability to still produce seed, even while under considerable stress. (Theoretically, the numbers of seeds shed by just one flower (up to 80) should be sufficient to re-build populations depleted by adverse circumstances. Fireweed thus has considerable 'spare' capacity to regenerate plant numbers in favourable fireweed years). Fireweed can also flower in sufficient numbers before organisms build up in sufficient numbers to impact on the population (Figure 21).

**Figure 21. Fireweed plants in September 2007 being attacked by a yellow rust fungus (*Puccinia lagenophorae*) (left); and a root-eating blue stem borer (right). In both cases plants had successfully set seed.**

Fireweed has been the subject of biological control programs in Australia and elsewhere (Sindel *et al*. 1998; Morin 2003; Louise Morin, personal communication, August 2007). Initially, high hopes were held for a flower-head feeding pyralid moth and a tip- and stem-boring tortricid moth, as well as a *Puccinia* rust fungus that was collected in South Africa.

Testing in Australia, found that the two insects had unacceptably wide host ranges – both in terms of native *Senecio* spp. as well as other genera within Asteraceae. The *Puccinia* rust fungus was found to be no more virulent than the species that already occurred in Australian fireweed populations. It was suspected to be the same species – exported from Australia to South Africa, then re-imported as a possible biological control agent! (A noted disadvantage of using rusts as biological control agents is the difficulty of producing spores on a scale large enough to use in bioherbicides).

The prospects of success for biological control of fireweed in Hawaii seemed higher than in Australia because the native flora contained no closely related species. But there have been problems there also. According to Kenneth Teramoto (Chief, Biological Control Section, Plant Pest Control Branch of the Hawaii Department of Agriculture (personal communication June 2007)), existence within the endemic flora of genera of Asteraceae that are threatened or endangered has required extensive and intensive host-specificity studies of potential agents.

The yellow Australian *Puccinia* rust fungus was not specific to fireweed, so after several years of research, this work was terminated. Of 11 insects that were imported in 1999, two were promising (a arctiid moth and a tephritid fly), both from South Africa. In 2006, these were lost due to technical reasons.

Another exploration took place in 2005, and the process of host-specific testing began again. There is some hope of the research continuing, and also that an agent will be released in the near future. However, despite the considerable investment, Dr. Teramoto pointed out that biological control of fireweed would not be the 'silver bullet' that producers had hoped for.

Biological control of fireweed will not be solved simply through investment. It depends on finding a host-specific agent that does not pose a direct or indirect threat to other ecosystems or ecosystem components. The search has already been thorough and extensive, which suggests that the cost of going further may outweigh potential benefits.

It is the case that further investment may simply reinforce the negative outcomes that have been experienced before. For these reasons, there is little impetus to re-commence a biological control program for the weed.

## 4.8 Synthesis of major issues

Three main themes are evident in research conducted into fireweed in Australia.

### 4.8.1 The Pyrrolizidine Alkaloid theme

This theme mainly concerned research or investigations into the realisation of the PA problem.

Problem definition mainly involved post mortem investigations of instances of cattle mortality, and linking clinical signs of PA poisoning *via* exposure and/or grazing circumstances to either *Senecio pinnatifolius* or *S. madagascarensis* (eg. Kirkland *et* al. 1982; Noble *et al*. 1994). Although PA poisoning and its clinical symptoms have long been known in European and American literature (eg. Hill *et al*. 1959; Cheeke 1987), and for some species, in the Australian literature also (see Sindel *et al*. 1998), the pen-feeding study by Walker and Kirkland (1981) was the primary Australian work that linked clinical signs of toxicosis in the field, to consumption of *S. pinnatifolius*. There was and may still be a problem in taxonomic differentiation of *S. pinnatifolius* and *S. madagascarensis*, and it is possible that some confusion has occurred as to which species were present in the pastures or used in the investigations.

As both species contain PA's, this seems on the surface not to be an important issue. However, as contain varying suites of PA compounds, and it is the metabolism of these compounds that results in PA toxicity, questions arise as to whether they pose the same risks to the various classes of livestock that may be exposed to grazing them.

This applies especially to sheep and goats. Throughout the 'soft' literature, the consistent view is stated that after more than several seasons of exposure, they are at a high risk of toxicosis. This seems an incorrect or inaccurate assertion, as it is based mainly on American/European work involving *S. jacobaea*, which is more toxic than fireweed. The view is not consistent with anecdotal experience, as some landholders have reported no ill effects in goats or sheep grazing fireweed for up to 6 consecutive seasons.

So what is the story? What PA's do Australian ecotypes of fireweed contain; which plant parts are the most toxic, and at what growth stages; and what impact do these PA's have on horses, cattle, sheep and goats, grazed at normal stocking rates on coastal pastures?

Associated with this PA theme, are questions relating to the risks posed by PA's to human health. The overwhelming evidence is that the risk of human exposure in harvested cereals is entirely preventable and that if it occurs in milk and honey, its levels are unlikely to pose a health risk (IPCS 1988; Painter and James 1990; ANZFA 2001; 2004).

(A recent study by Somerville (2001), found fireweed was a poor source of bee pollen because it was not a major nectar producer; and that the crude protein levels in its pollen were well below that needed for maintenance of healthy bees).

In relation to meat, the consensus view in the literature is that PA's and their toxic derivatives are excreted very rapidly and do not accumulate in tissue.

The final major point in relation to this theme, is that although fireweed (and presumably other PA-containing plants, including possibly endophyte-infected fescue and ryegrass), reputedly contributes to the syndrome referred to as 'coastal ill-thrift', no scientific evidence could be located that objectively established its importance.

(The experience of one feedlot operator in North-Western NSW that was contacted, was that cattle sourced from coastal districts were frequently 'loaded' with liver fluke and internal parasites, which combined with issues related to acclimatisation, made their feedlotting uneconomic).

Nutrient and mineral deficiencies may also contribute to 'ill-thrift' and for the coastal cattle industry, it is an unsatisfactory situation to have a range of potentially separate issues viewed as a 'syndrome'.

#### 4.8.1.1 Questions left unanswered

- There is no easily sourced data detailing the specific PA's and their concentration in Australian ecotypes of fireweed.
- The specific contribution of fireweed to the 'ill-thrift' syndrome.

### 4.8.2 Fireweed ecology

The second theme involved research and investigations into the ecology, population dynamics, weediness and potential distribution of fireweed.

Although there have been several major studies into aspects of the biology and comparative genetics of fireweed, in Australia, there has only been one comprehensive field-based research project (Sindel 1989). This Ph.D study was mainly conducted in the Cumberland District, west and southwest of Sydney. Sindel subsequently published a range of papers relating to his Thesis; and an updated version of his earlier comprehensive dissertation (Sindel *et al*. 1998), as part of the series *The Biology of Australian Weeds*. This work, and a range of relatively minor, but nevertheless significant contributions published mainly in conference proceedings, together with the study by Martin and Colemen (1977) on the North Coast, represents almost the entire body of Australian knowledge related to fireweed.

(Sindel *et al*.'s (1998) review was the source document for many of the more recent advisory and extension ('soft-science') publications put out by various agriculture agencies. Material in these secondary publications, in many cases in simplified form, has flowed through to tertiary levels of knowledge dissemination including publications by catchment management bodies (within and outside NSW), local government, native plant societies and the wide range of people and organisations that have published something, even internet blogs, about fireweed. (Some of the messages have even been recorded in the NSW and Commonwealth Hansard!).

#### 4.8.2.1 Questions left unanswered

No one interviewed for this project was aware of any fireweed research *per se.* having been conducted on the South Coast. The most important issue this raises is the actual effect of fireweed on pasture production.

There are several important areas of local concern that have not been addressed by the research conducted elsewhere. These are:

- How far will fireweed it spread, and at the limits of its current distribution, is it a significant ongoing threat, or will it stabilise as single or multiple plant populations?

  (Research into its potential distribution has been undertaken using a modelling approach, and should therefore be viewed as indicative, and in need of verification. Monitoring sites at locations where single or low-density stands have been located could be used to track numbers in populations and thus establish some trends that could be compared with predictions).

- To what extent does its low palatability deter grazing; and can benchmarks be provided to guide landholders in their management decisions in relation to fireweed?
- How much is too much; and under what conditions is it particularly virulent?
- For the types of pastures that occur on the South Coast (dominantly low-input kikuyu, kangaroo grass and weeping grass pastures), to what extent can management strategies be used to reduce the fireweed hazard?

  (‘Better management’ is often stated as a control option, but most landholders cannot envisage a workable management system that may reduce the severity of infestations, or improve the resilience of existing pastures).

### 4.8.3 Control of fireweed

Three reasons make this theme the most contentious. The first is that, historically, Bega Valley and Eurobodalla Shire landholders were dominantly dairy and later beef producers. Even though some have successfully done so, many cannot envisage a change in their enterprise mix as a way of dealing with the fireweed challenge.

The second issue, is that most producers lack the financial and time resources to embark on herbicide programs, especially when success rates seem low, costs seem high, and they are concurrently dealing with drought, escalating costs and low-margins or unstable market prices for their products.

The third issue, which is related to the other two, is that expectations of a successful biological control program have been raised to the point that some producers seem almost ‘certain’ that a magic bullet is waiting in the wings.

#### 4.8.3.1 Use of sheep and goats

Inclusion of sheep and goats in the enterprise mix is already gradually happening. Provision of a greater level of institutional support, together with locally relevant information; improved networking and marketing would accelerate the trend.

The general call is for less information, and more hands-on, experience-based learning.

#### 4.8.3.1.1 Questions left unanswered

- Aside from issues of long-term PA exposure; for goats at least, there are unresolved animal health issues (mainly drenches for internal parasites); there is a need for easily understood ‘one-shop-stop’ protocols (as distinct from information) for moving and purchasing goats and sheep within and between districts, especially in relation to footrot and Ovine Johne's disease (most information on OJD forgets to mention goats). Protocols in a checklist format would be very handy.
- On the practical side, for many producers, seeing is believing. Landholders who have little experience in managing sheep and goats could gain from existing producers willing to share essential knowledge and skill. At the outset this process would need facilitation by appropriate professionals. It would aim to reach traditional producers, as well as the growing number of small-area landowners moving into the district.
- In terms of research gaps, issues such as how to best co-manage relatively small flocks of sheep or goats with cattle; the effect of them on the feed supply; their effects on weeds, and pasture health generally are all issues of concern.

### 4.8.3.2 Use of herbicides

The main questions relating to herbicide use concern efficacy, efficiency and longevity, which are the primary factors impacting on cost.

- Efficacy is the interaction between a particular herbicide; its timing of application; and the balance between its impact on the target weed and unintended, non-target collateral effects.
- Efficiency, is related to how many times a particular herbicide needs to be applied/season to achieve control. Timing is an issue, but of equal importance for fireweed, is residual control of succeeding germination cohorts.
- Longevity determines the effectiveness time-line.

#### 4.8.3.2.1 Questions left unanswered

- How to get it right. Simple, strategically located demonstration-type experiments, could be used as both an extension tool and as a lasting reminder to local landholders of the critical importance of using the most effective herbicide, at the correct rate, and during the best time-window. The Eurobodalla Fireweed Committee, and some members of the Bega Committee, strongly supported this approach.
- Many producers see the need for up to date ‘handy’ information relating to fireweed and herbicide use.

  Local and regional management plans setting out aspirational goals, are seen as generally no use to the producers who are ultimately charged with the responsibility of doing something. This points to a wider institutional problem that producers see as outside their sphere of influence.

### 4.8.3.3 Biological control

As frustrating as the outcome may be, the biological control issue will eventually play itself out.

A new program will start or it will not; if it does, it will either be successful or it won't. If an organism passed all its tests, and was successfully released it would either have a significant impact on fireweed populations or it would make little or no difference.

Predicting an outcome and its possible significance at this stage would be highly speculative.

## 4.9 Prioritised actions for tackling fireweed on the South Coast of NSW

This section of the report focuses on delivery actions aimed to develop the skill, knowledge and confidence of stakeholders, including those implementing weed control strategies at the Local Government level; those recommending or retailing products for particular situations; as well as landholders.

### 4.9.1 The technical basis for planning weed control actions; and planning for success

It is a problem that there are numerous sources of fireweed information, some of which is alarmist, inaccurate, incomplete, or not locally relevant. It is also an issue that weed control management plans are seen to be vague non-purposeful documents that lack relevance to stakeholders. The following actions are recommended:

- Get agreement and consensus from stakeholders, based on relevant, 'handy' locally applicable information.
    - Target what it is that people *on the South Coast* want to know about fireweed. For example:
        - How bad is it really, if I have it?
        - How much of it is too much?
        - Can I expect to get it, if I don't have it yet?
    - Integrate existing knowledge into local weed management plans Formulate a SMARTA[2] (Specific; Measurable; Achievable; Realistic; Time-bound; Agreed) Regional approach. This requires input from across State Government Agencies (DPI and CMA); Local Government; produce agencies and spraying contractors.
    - Test the knowledge (eg. is it handy?); the medium (print, radio etc.); and the delivery mode (eg. mailout; 'on the counter'; on-display etc.).
- Establish a workable action timeline based on the ecology of the weed. Figure 22 presents a tentative example of this.
    - Three phases could be envisaged.

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[2] SMARTA actions with fireweed

**S**pecific knowledge that is handy for the situation.
**M**easurable ways of benchmarking success.
**A**chievable outcomes - doing it once, doing it well and within budget.
**R**ealistic expectations of doing the job within the constraints of time and capacity.
**T**imeliness in getting onto the problem.
**A**greement in doing what is required.

- An action phase, where options and reasons for doing something are left fresh in landholder's minds immediately prior to the implementation window.
- An implementation phase, which may involve for example, demonstration or assistance in the field (field days) with equipment calibration and testing; as well as further discussion of options.
- An evaluation phase, integrated with planning actions for the following year.

- Key factors that underpin success include:
  - Messages need to be accurate and consistent.
  - A 'have to do' big-stick approach is moderated by landholders 'learning by doing'. Demonstrations and field days are vital components of the approach.

### 4.9.1.1 Proposed actions

- Organise a workshop of people and organisations charged with implementation of weed strategies, specifically to pool ideas in the development of a format for standardised (or possibly regionally focussed), 'handy' weed control packages for regionally important weeds.
- Focussing on fireweed and lovegrass, there is a need to resolve some of the more important issues causing concern in South Coast communities.
- Concerns specifically related to PA risks in cattle, sheep and goats should be investigated, and resolved, together with questions relating to the impact of fireweed on pasture productivity and health.

<table>
<tr><td colspan="2">Explanation</td><td colspan="7">Most plants established by end of May. Herbicides effective up to the end of July rapidly decline in effectiveness up to the end of August.</td><td colspan="2">Nil prospect of herbicide success</td><td colspan="2">This is the on-farm planning window</td></tr>
<tr><td>Plant stage</td><td>Dead</td><td colspan="4">Increasing germination of cohorts >>>>></td><td colspan="3">Establishment and early growth<br>(Slow growth in July)</td><td colspan="2">Flowering and senescence</td><td colspan="2">Death</td></tr>
<tr><td>Colour code</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Month</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May[1]</td><td>June[1]</td><td>July</td><td>Aug[1]</td><td>Sept</td><td>Oct</td><td>Nov</td><td>Dec</td></tr>
<tr><td>Best tools for the job</td><td colspan="2">Critical to avoid herbicide use.</td><td colspan="3">Jaguar most useful and cost-effective</td><td colspan="3">Bromoxynil effective up to the end of August, but at increasing rate and cost</td><td colspan="4">Avoid herbicide use; success and evaluation period; plan implementation strategies for next year.</td></tr>
<tr><td>LGA Actions</td><td colspan="3">Extension; establish agreed action 'contracts'; mailout.</td><td colspan="2">Encourage early intervention (radio; TV etc)</td><td colspan="3">Monitor implementation of plan</td><td colspan="4">Check results; plan for next year.</td></tr>
<tr><td>Supplier actions</td><td colspan="5">Encourage use of most effective herbicide for the job (a flow-chart decision support tool would be useful)</td><td colspan="7">Discourage late or out-of-season herbicide application.</td></tr>
</table>

[1]For landholders, May and June are critical decision months for action. August and September are critical decision months to cease using herbicide. In the absence of more critical guidelines, using herbicides in August may still be contemplated in years when there are 4 times the numbers of young non-flowering plants than older flowering plants.

**Figure 22. An example of a possible decision support tool that integrates the roles of weed authorities (Local Government), and advisors (in this case rural suppliers) into a possible control program for fireweed.**

### 4.9.2 Encourage success

There is a need for more landholders to experience 'success' in controlling weeds than they experience failure. This is not due to a lack of technical information; in some respects there is too much; it is due to the lack of demonstrable successful outcomes. Four strategies are envisaged.

- Show stakeholders.
- Involve stakeholders
- Remind stakeholders.
- Let stakeholders evaluate the outcome.

Within this group of actions, there is also a need to demonstrate/evaluate the success or otherwise of controlling the spread of fireweed (and lovegrass), into areas where it is not established at weed proportions, and thus predict if it is likely to establish in weed proportions.

#### 4.9.2.1 Proposed actions to encourage success

##### 4.9.2.1.1 For herbicides:

- At strategic locations where results can be easily observed, set up realistically scaled, replicated, herbicide demonstration trials (strips running at right-angles to a fence) with signs on the fence indicating herbicide used; rate; and time of spraying. Involve stakeholders in all aspects of setting up, spraying, and evaluation. Data of value to stakeholders should be collected from these experiments and used for extension. Minimum data should include, estimates of plant numbers; number of cohorts; contribution to composition (BOTANAL), and herbage mass at the end of October.
- Sites could be used to develop a simple rating system to help landholders get a feel for fireweed toleration thresholds (via direct participation)..

##### 4.9.2.1.2 For sheep and goats:

- More detailed surveying of landholders who have successfully integrated sheep and goats into their cattle-based production systems, including issues related to production, marketing, animal health, and enterprise (flock and herd) management.
- Undertake a pasture survey across the South Coast Districts to objectively determine (i) the extent of the fireweed problem; (ii) the impact of fireweed on productivity and production; and (iii) obtain data that may be used to assess rate and direction of spread.
- Instigate regular field days or farm walks involving experts in sheep and goat husbandry that coincide with the times when husbandry actions, need to be undertaken. The form of these days could involve presentation and discussion of issues; followed by a farm walk for hands-on demonstration, or inspection of, for example, workable make-do shearing sheds, fencing options etc.

##### 4.9.2.1.3 For adjoining LGA's

- Set up monitoring sites along transport corridors, where fireweed occurs in sporadic multiple-plant stands, to determine the extent to which natural increase, or continuing seed rain from passing traffic may result in infestation-like populations. Two parameters should be monitored over 3 years (i) the timing and numbers of individuals that establish; (ii) the number of cohorts present at flowering and the success of seed-set.

## 4.10 Tools

Major deficiencies in pertinent field-collected data are a barrier to designing tools that may be useful for benchmarking or tracking the need for, or success of, fireweed and lovegrass control strategies. For example, as already highlighted, for the pastures that occur on the South Coast, and the relatively dry circumstances that have prevailed the past 14 years, there is no published information relating the presence of fireweed to pasture productivity. (Data of Martin and Coleman 1977 did not indicate a negative interaction between fireweed and pasture growth, so the question is unresolved).

Nevertheless, tools could be developed to assist people in deciding on particular strategies such as the use of herbicides *vs*. 'weeders'; and for 'weeders', development of profit motivated enterprises.

These include:

- A SWOT (strengths, weaknesses, opportunities and cost) analysis framework for a range of options that may be considered.
- Planning tools, such as business plan that a landholder may be encouraged to present to the bank to finance a new business.
- An 'in-the-back-of-the-mind' goal, to simply do something, a little each year, just to stay in front of the problem.

Tools could also be developed to assist in deciding the time to act, and the timing of the actions.

These may include:

- A template for estimating the severity of the problem – an average number of fireweed plants/paddock for instance, to assist in planning actions for the next year.
- A pictorial *When to spray* guide (see Appendix 2).
- A farm plan or property sketches, detailing the location of 'hot-spots' that need to be treated.
- A photograph album that could be digital, to track events through the year.
- Paddock diaries for planning stock movements in advance, to accommodate specified withholding periods after herbicide is applied.

Tools could be developed to monitor and analyse outcomes.

These may include:

- A structured photograph album, or glove-box note book
- The use of photo-points
- Field days
- Promulgation of success stories in local media
- Case studies

# 5 Success in Achieving Objectives

The objectives of the project have been broadly achieved. The report has attempted to address most of the concerns expressed by South Coast producers; it has presented an analysis of control options; and it has highlighted the main factors relating to the success of control programs.

## 5.1 Knowledge gaps

Knowledge gaps have also been highlighted. These fall into 3 main categories:

- The effect of fireweed on production.
    - This is an issue that directly impacts on the economics of control.
- The effect of fireweed on cattle, sheep and goats, under normal paddock conditions.
    - This impacts animal health and productivity.
- Efficacy of control options
    - This impacts on the willingness of landholders to act.

## 5.2 Economic analysis of candidate fireweed management options in the differing production contexts

As the project progressed it became apparent that there was no real basis on which meaningful economic data could be utilised. The reasons for this were:

- In the Bega Valley, sown dryland temperate pastures costing $200 to $700/ha. rarely last more than 3 to 5 years (Harry Kemp, personal communication, September 2007). Under the present climate scenario (Figure 4), risks are unacceptably high. At benchmark stocking rates for the past 14 years of 14 DSE, and returns that rarely exceed $2.00 kg, on a turn-over of about 20 months for vealers, using high-input pastures for a beef production scenario is not economic.
- Currently there is no reliable objective evidence indicating relationships between the level of fireweed in pasture and the productivity of that pasture. Without this information an economic analysis is inappropriate and could be quite misleading.
- In the short term the best approach is to relate the cost of controlling fireweed to the amount of extra production required to cover this cost. For example, if the control cost is $40 per hectare, then, at $2.00 per kilogram live weight, an extra 20 kg of live weight per hectare must be produced to cover the cost. This is a direct linear relationship.

To give a better perspective to the impact of fireweed on grazing systems and to allow a meaningful economic analysis, it is necessary to have objective data showing the impact of different levels of fireweed on:

- Pasture productivity. (There may be an interaction between fireweed and soil fertility that needs to be defined as well).
- Pasture composition. (eg. Does fireweed impact on some pasture species more than others?)
- Stocking rate. (Is it higher with no fireweed; or is just rainfall dependent (eg. Table 3))?

- Daily growth rate of stock.
- Reproductive rate.
- Stock health (which may or may not be fireweed related).

Data would be needed in both the short term and the long term.

Data is also needed to show how long a treatment program lasts. For example, if spraying reduces the amount of fireweed in a pasture to <1%, how long until the level builds again to a “critical” level? The “critical” level also needs to be defined – if there is one. It may be that there is a steady linear relationship between the level of fireweed and the above factors.

## 5.3 Best management guides

Although all the data needed to develop best management guides are contained within the report, the guides themselves have not been developed. Developing guides within the context of local weed management control plans has been stressed as the most viable way forward, and is strongly recommended. BMG’s should also draw on the considerable experience of weed control officers from both the South Coast and other areas where fireweed has been a problem for a considerably longer time, so they are universally useful.

Compiling the report has provided insights into what people want to know; and how they want the messages to be related. It is clear that they do not want to read it, or be lectured about it; they need to see it. There is also a pressing need to get past the present feeling of hopelessness and failure, because this is a major barrier to encouraging action.

## 5.4 A framework for action

An action plan has been proposed that consists of a mix of:

- Administrative and extension action that integrates knowledge with advisory-compliance activity.
- Success-oriented demonstrations of herbicide use, within a co-learning framework.
- Emphases on co-learning and skills development in respect of sheep and goats, involving specialists and local landholders.
- Investigations. Pasture surveys and monitoring to study the extent and impact of fireweed across the region; further studies related to animal health; specifically, the contribution of fireweed in the syndrome referred to as ‘coastal ill-thrift’.

# 6 Impact on the Industry – now & in five years time

## 6.1 Immediate impact

There is an identified knowledge gap on the South Coast in respect of local impact of fireweed on production and products. This is evidenced by the depth of concern expressed by individuals in the community; the large numbers of people that have attended various public meetings; issues that have been raised in the local media; and political agitation. At an individual landholder level, opinion is divided as to the true threat it poses.

**Improving the availability of locally relevant knowledge, which assists landholders to make decisive and timely decisions, will be major advance on the current situation.**

Integrating the knowledge within local Weed Management Plans, and developing a knowledge-based extension and enforcement strategy will also be an advance. Landholders consistently want ‘handy’ information, all in the one place, in a format they can directly use. They are generally not good at searching for it themselves.

**Demonstrating the pathways to successful fireweed management, using herbicides or sheep and goats, in a hands-on way will generate confidence and also contribute to success.**

This project represents a preliminary ‘look around’ at the issues and possible solutions. It is now important to maintain the momentum and to start some on-ground work. It is the implementation of the follow-through work that will drive success.

## 6.2 Future impact

It is of great surprise that there exists a bundled syndrome referred to as ‘coastal Ill-thrift’ that all the ills of poorly performing cattle, including toxicity that could be related to fireweed, disappear into. This syndrome, which has been around for more than half a century, is blamed for deaths in feedlots; low growth rates; seedy-looking calves with poor market prospects etc.

Resolving the complexity of this syndrome, not just the relative contribution of fireweed, but also the contribution of other factors/issues would impact greatly on the productivity of coastal beef and dairy producers.

We can already draw up a list of contributing factors, but how important are they in a hierarchical sense? Would producers be better off investing in better pastures, animal health, genetics, mineral supplements, or fireweed, or all things in equal measure? Are cattle being over-treated for problems that they do not have, at the expense of something they do?

In terms of the work undertaken here, in the future landholders will be more comfortable with making decisions about fireweed control, because they will also be more successful. We may see many more sheep and goats in the Bega Valley; generating proportionally more income, while solving some of its problems. As farms become smaller, sheep and goats may become more viable. We may also see more robust management strategies, involving sheep or goats integrated within present beef and dairy industries.

Up-scaling in numbers of sheep and goats will contribute to their viability as commercial ventures; there are also business opportunities both on-and off farm that could be contemplated in response to the fireweed issue.

# 7 Conclusions and Recommendations

Fireweed is a major concern to producers on the South Coast of NSW. It is very visible in spring; it has been linked to mortality and possibly ill-thrift in cattle and horses; it has spread over wide areas despite earnest attempts by local weed authorities and many landholders to control it; and there are fears that it will continue to spread westwards from the Valley across the Monaro and Tablelands.

## 7.1 Effect on the environment

Fireweed is most dominant in heavily grazed, fertile pastures and on disturbed sites. Its frequency in grazed tussock-grass pastures is low; it is infrequent to absent in frost-hollows and undisturbed roadsides, and it is not found within native forests. This is not disputed, and therefore it is not an area of priority enquiry.

## 7.2 Ecology

Its germination is controlled by light and moisture; while its establishment ‘success’ is determined by the age of individual cohorts at the time and intensity of the first major frost. In late spring to mid-summer, fireweed sets massive numbers of seeds/plant and /$m^2$; when conditions are suitable in late summer and autumn, these germinate in massive numbers as waves of cohorts. Through inter- and intra-specific competition and other factors, seedlings perish in massive numbers, so that in situations where it is favoured, mature stands of normally-sized plants (300 mm high by around 200 mm in diameter) rarely consist of more than 20plants/$m^2$. Seedlings establishing in late spring to mid-summer rarely survive. Measures that target pre-flowering young plants (herbicide), or that prevent flowering and seed (selective grazing by sheep or goats) offer the best chance of control.

The cohort-story is important, and the impact of 1-off applications of the range of available herbicides on the successive germination pattern could be a deciding issue in their effectiveness. This needs to be researched at a small scale.

## 7.3 Effect on pasture production

Fireweed is most competitive, and grazed pastures least competitive under conditions of low spring and mid- to late-summer rainfall. It is believed that fireweed arrived on the South Coast during drought and that it established as a weed during drought. Its progressive spread over the past 9 years, has coincided also with a lengthy period of below-average rainfall. This is consistent with its behaviour elsewhere, and with its ecological role as a pioneering species. African lovegrass shares similar characteristics.

Anecdotally, fireweed is believed to have a negative impact on pasture production. However there is a lack of data relevant to South Coast pastures to indicate this is the case. Because the majority of South Coast pastures are low-input, and they mainly consist of $C_4$ summer-growing grasses, published data relating to sown temperate pastures, or cereals (oats), do not apply. Observations suggest also, that because it germinates early (February to March) and its habit is not prostrate, fireweed is not directly competitive with pasture legumes, which do not commence growth until late autumn (in the case of subterranean clover) or in spring (white clover). It seems to be only kikuyu and the summer growing grasses that offer competition.

In the absence of some understanding of the productive impact of ridding pastures of fireweed, economic analysis of removal strategies would be misleading.

## 7.4 Effect on livestock

The main risk faced by livestock grazing fireweed is the consumption of pyrrolizidine alkaloids (PA’s). Although benign in the plant, these compounds are metabolised in the liver into a range of rapidly excreted metabolites, which in the process, causes irreparable liver damage. Thus although there is no evidence that the compounds are retained in tissue, the damage done is both cumulative and progressive. Sheep and goats are many times (reputedly 20 times) more tolerant of PA’s than horses and cattle. However, the effect of long-term exposure specifically to fireweed has not been determined. **This is an issue that should be resolved**.

The palatability of PA containing plants to susceptible species of livestock is low. Nevertheless, mortality amongst cattle grazing pastures infested pastures has been recorded. Instances have most often occurred during drought years; and the total numbers of cattle involved relative to total numbers in a district have been small. **However, there is a need to establish tolerance benchmarks for pastures in fireweed prone districts, so landholders can take timely action in order to avoid mortality.**

Sub-lethal, consistent, accidental intake of fireweed may result in ill-thrift in some classes of animals. The problem this presents needs to be investigated as part of an overall assessment of the components of the syndrome commonly referred to as ‘coastal ill-thrift’ which is reported throughout coastal Australia.

Throughout coastal Australia, Ill-thrift is used as the ‘throw-away’ syndrome for undiagnosed cattle ills. It potentially hides a number of serious, and possibly preventable problems, which reputably impact on cattle health and productivity.

**Coastal ill-thrift is an issue that has not been resolved, but which could have significant ramifications for the industry and should be investigated further. For fireweed there is an existent product assurance problem concerning the persistence of toxins in meat products and the effect of toxins on specific organs, mainly the liver, which deserves further investigation.**

## 7.5 Control of fireweed

### 7.5.1 Herbicides

Several brands of straight bromoxynil 200/g/L a.i. herbicides, and three other trade-named herbicides are currently registered for fireweed control/suppression. (According to its label, Tigrex, which targets a range of MCPA-susceptible weeds, only suppresses fireweed, so it is potentially less useful against fireweed alone). Although Hotshot will kill fireweed at all growth stages, according to its label, it is lethal towards pasture legumes; it has a lengthy (up to 3 seasons) plant-back period for legumes, and it has lengthy and complex withholding periods especially for cattle bound for export.

The bromoxynil-based herbicides seem the safest options for use in pastures, and of these, Jaguar is more cost-effective on seedling fireweed plants, and it is observed to exert residual control (via. Diflufenican) of germination of successive fireweed cohorts.

In the district, fireweed is generally sprayed at growth stages too late to be effective, and therefore at unrealistically high and expensive rates, and often repeatedly through the year. A high proportion of late-sprayed plants, and/or plants that are slashed post-flowering, re-shoot; they seem reinvigorated by the treatments, and they often continue to grow and flower well into the following year. This undermines any further attempts at control. Late spraying also incurs the risk of developing populations that are relatively resistant to bromoxynil, which would be potentially a disastrous outcome.

**Spraying 2 to 3 weeks after the first major rainfall (>30 mm) after the end of February, using Jaguar, seems to be the most succinct and effective recommendation, and this should be the basis on which demonstrations should be timed.**

### 7.5.2 Sheep and goats

Sheep and goats find actively growing fireweed tissue (new leaf and shoots), and especially flowers particularly palatable. By maintaining grazing pressure on fireweed during its growing season, they considerably reduce the reproductive capacity of the weed, but do not eliminate it. Landholdings grazed by sheep and goats either as enterprises in their own right, or as ‘weeders’ are invariably, and by many degrees, cleaner of fireweed. However, there are numerous structural and infrastructure barriers to adoption.

Numbers of goats in the district are gradually increasing; numbers of sheep have remained fairly static. This possibly reflects the influx of new people entering the district, as retirees and life-style seekers, who take up small landholdings (<50 ha), and graze goats in preference to sheep, as a hobby, interest or business. There is growing interest in Dorper sheep, because they require less investment in infrastructure, particularly shearing facilities.

Although many landholders perceive barriers to the adoption of alternative means of reducing the impact of fireweed as significant, there are many examples of low-cost ‘make-do’ solutions. For traditional dairy-beef producers, and indeed the many new people entering the district, issues of skill and experience with sheep and goats (and herbicides) is a significant barrier.

People that are unable to undertake their own research or conceptualise from printed or other media, need ‘hands-on’ exposure to new ideas. **Field days, farm walks, and learning groups focussing on the issues that they are concerned about, would be a useful approach to speed adoption.**

Increasing the numbers of sheep and goats in South Coast districts may have a number of flow-on advantages relating to scale of operations. However, it is problematical that advisory and research services for these industries have contracted, and that the nearest advisory offices are at Cooma, Wagga Wagga and Goulburn. It is also an issue that much of the information available is dispersed and presented in a ‘soft’ non-specific, formally structured format, which many producers do not find ‘handy’.

**In undertaking this review, it became clear that in relation to almost every aspect of fireweed and its control, there is too much information; and too much of it is not much use! The most recent DPI Fireweed Primefact (Allen et al. 2005) is a case in point.**

## 7.6 Recommendations

Investigations involving fireweed (and African Lovegrass), and demonstrations of control techniques on the South Coast, should specifically address concerns expressed by local producers; and target the various factors that have contributed to their perceived lack of success in dealing with the weed.

A secondary, but equally pressing concern is overcoming barriers to adoption, which includes elements of skill, knowledge and experience; as well as ‘can-do’ approaches to issues such as infrastructure; mainly minimum cost fences; adaptable shearing sheds; portable or permanent yards etc.

### 7.6.1 General recommendations

***Local weed management plans need to be developed into user-friendly ‘handy’ documents. These need to:***

- Clearly state the obligations of the various parties to the plan;
- They should not contain aspirational, ‘wooly’ or impractical strategies or goals;
- Focus strictly on what can be done within the boundaries of the farm;
- State what the recommended practices are; and,
- Detail the success criteria.

They should do this in sufficient, succinct detail, so that a landholder picking up the document can understand their obligations and do something, with the assurance of a reasonable chance of success.

Other advisory information that may accompany a management plan should contain ‘less sauce and more meat’ (a landholder quote).

***Issues related to animal health need to be resolved as high priority.***

- For cattle, fireweed should not be seen as some vague problem contributing to a vague syndrome. It is either a problem or it is not, and if it is, its relative importance across the district needs to be determined. It is unsatisfactory to have a ‘garbage-bin’ syndrome that all manner of specific, production-limiting and potentially lethal problems can be tossed into.

  (Despite being widely acknowledged as a major issue, there is currently no specific information in Agfact or Primefact format dealing with the syndrome of coastal ill-thrift).

- For sheep and goats there is currently no data to hand specifically detailing the effect on sheep and goats of fireweed (as distinct from PA’s generally). The main questions relate to long-term exposure to grazing fireweed. This needs to be resolved in order to develop sound guidelines for recommended practice.

### 7.6.2 Recommendations relating to the spread of fireweed

A small-scale monitoring project would answer most of the questions relating to the potential for fireweed to spread, particularly to the west.

The present strategy of hand-removal along roadsides and on private land is unsustainable and an inefficient use of resources. If fireweed can be shown to increase its density significantly, provided it was well timed, a on-off roadside herbicide strategy would be more effective, and it would more completely deal with the problem than hand-pulling, which is tedious, risky for operators working near roadsides, and inefficient at removing all plants.

### 7.6.3 Recommendations in relation to herbicides

- Strategically located demonstrations of all registered herbicides, adjacent to roads where passing landholders can continuously observe responses (eg strips at right-angles to the road; with clear labels on the fence indicating herbicide; rate and cost; and time of application. These are the most important issues.
- (Adequate room for parking and at least 300 m of clear vision each side of site (RTA requirements), should be allowed).
- Demonstrations should be replicated and response variables measured.
- Demonstrations should be backed up by on-farm paddock-scale best practice demonstrations; to serve as a focus for field days and farm walks.
- Encourage people to monitor and evaluate the success of their own herbicide strategies, using photo points, measurement tools or ratings. Protocols for these, and the tools themselves need to be developed in consultation with stakeholders.

### 7.6.4 Recommendations relating to sheep and goats

These offer the greatest potential for the management of fireweed in the long-term. Current trends towards increasing numbers of goats in the district need to be encouraged by regular field days, farm walks and mentored learning. Hands-on learning, and make-do approaches is the recommended focus. Landcare groups could become more active in promoting this.

- The main recommendation in relation to this is that a delivery model for hands-on learning be worked out in consultation with key existing sheep and goat producers, interested landholders and advisors.
- A research or investigation component of assessing the efficacy of sheep and goats, relative to cattle should focus on pasture health by way of a rigorously implemented survey of pastures across South Coast Districts. The survey should be scientifically credible, and it should embrace the main pasture types of the district.

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# 9 Appendices

## 9.1 Appendix 1. Fireweed Weed Management Plans for Bega Valley and Eurobodalla Shires.

### BEGA VALLEY SHIRE COUNCIL

Fireweed Management Plan

Aim
To specify the control measures required for Fireweed (*Senecio madagascariensis*) within the Bega Valley Shire.

Statutory basis
By Order 20 of 31 August 2006 made by the Minister for Primary Industries pursuant to Sections 7 and 8 of the *Noxious Weeds Act 1993* (Order 20).

Control objective
To minimise the impact of Fireweed (*Senecio madagascariensis*) on the economy, community and environment of NSW.

Control class
Pursuant to Order 20 Fireweed (*Senecio madagascariensis*) is a declared Class 4 noxious weed.

Control measure
Order 20 specifies that for Class 4 noxious weeds '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'.

Management plan
Actions for the management of Fireweed (*Senecio madagascariensis*) which apply to the Bega Valley Shire Council area are listed in the Table below.

| Infestation situation | Control measures specified |
|---|---|
| All infestations | Chemical, mechanical, physical, cultural means or a combination of these methods.<br><br>All precautions must be taken to ensure that produce, soil, livestock, vehicles, plant and machinery are free of the weed prior to their sale or movement from infested lands. |
| Designated rare and isolated infestations (includes light or scattered infestations) | Fireweed must be suppressed and destroyed. |
| Designated marginal and core infestations | Fireweed must be suppressed within fifty metres of property boundaries, creeks and waterways, access roads and tracks in identified priority areas to complement adjoining management programs (including those on roadsides and public lands) and reduce the likelihood of spread onto neighbouring land.<br><br>Management may include an agreed grazing management plan. |

Enforcement
Failure to comply may result in Council taking further action which may include implementation of controls by Council at the owner or occupier's expense and legal action and fines under the *Noxious Weeds Act 1993*.

## 9.2 Appendix 2 A Pictorial *when to spray* guide

**Figure 23. Germinating 1st cohort – too early to spray**

**Figure 24. 1st cohort at 4-leaf stage; 2nd cohort germinating – earliest time to spray.**

**Figure 25. Plants 2-3 weeks old, growing vigorously; temperatures falling below 20°C; clover at the 2-4 leaf stage. This is the optimum time to spray with Jaguar.**

**Figure 26. After plants flower, it is too late to spray with anything.**

## 9.3 Appendix 3. Delivery actions for fireweed - Summary of a workshop in Bega on 28 February, 2008

**Background:**

The MLA-commissioned report provided recommendations to assist management of Fireweed. The usefulness and relevance of the recommendations were discussed in a facilitated workshop setting at Bega Feb 28, 2008. Discussion of these outcomes concludes the MLA report.

For the main recommendations relating to products or processes, a common set of questions was asked of the group. These were:

1) Relevance of the proposed action or product

2) Suggestions for improvement

3) Likelihood of use by participants

These suggestions are in the public domain for all interested groups to progress as appropriate.

**Products/ Processes arising from the Report:**

### 1) FACT SHEET DESCRIBING GROWTH STAGES, AND APPROPRIATE TACTICS BY SEASON FOR CONTROL

| Explanation | | Most plants established by end of May. Herbicides effective up to the end of July rapidly decline in effectiveness up to the end of August. | | | | | | | Nil prospect of herbicide success | | This is the on-farm planning window | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant stage | Dead | Increasing germination of cohorts >>>>> | | | | Establishment and early growth (Slow growth in July) | | | Flowering and senescence | | Death | |
| Colour code | | | | | | | | | | | | |
| Month | Jan | Feb | Mar | Apr | May[1] | June[1] | July | Aug[1] | Sept | Oct | Nov | Dec |
| Best tools for the job | Critical to avoid herbicide use. | | Jaguar most useful and cost-effective | | | Bromoxynil effective up to the end of August, but at increasing rate and cost | | | Avoid herbicide use; success and evaluation period; plan implementation strategies for next year. | | | |
| LGA Actions | Extension; establish agreed action 'contracts'; mailout. | | | Encourage early intervention (radio; TV etc) | | Monitor implementation of plan | | | Check results; plan for next year. | | | |
| Supplier actions | Encourage use of most effective herbicide for the job (a flow-chart decision support tool would be useful) | | | | | Discourage late or out-of-season herbicide application. | | | | | | |

[1]For landholders, May and June are critical decision months for action. August and September are critical decision months to cease using herbicide. In the absence of more critical guidelines, using herbicides in August may still be contemplated in years when there are 4 times the numbers of young non-flowering plants than older flowering plants.

**Figure 17. An example of a possible decision support tool that integrates the roles of weed authorities (Local Government), and advisors (in this case rural suppliers) into a possible control program for fireweed.**

**a) Relevance of the proposed action for success in management - High**

**b) Suggestions for improvement:**

- Technical meeting t required to review chemicals, timing and rates
- Include all registered chemicals

- Include 'don't do actions ' such as slashing, grazing duration, timing
- Seasonal conditions need to be addressed (eg early rains then…; late rains then…). That is, the seasonal management calendar is not rigid and is driven by opening rains
- Use "plant growth" stages not "months", as the driver for action
- Be instructive at each growth stage – what to do and *not to do*
- Emphasise 'look in the paddock' for visual signs
- High priority is to emphasise "look in October" to determine actions for the following autumn.

**c) Usefulness and Likelihood of "use" by participants: 4/5 - Helpful & Frequent use**

**2) HIGHLY VISIBLE DEMONSTRATION SITE OF CHEMICAL CONTROL**

At strategic locations where results can be easily observed, set up realistically scaled, replicated, herbicide demonstration trials (strips running at right-angles to a fence) with signs on the fence indicating herbicide used; rate; and time of spraying.

**a) Relevance of the proposed action for success in management - High / Medium**

**b) Suggestions for improvement:**

- Chemicals control needs clarification – what is best and when
- Capture new chemicals - set up as a chemical control experiment. A demonstration should be on farm and bigger scale.
- Demo of chemicals x timing required
- Build in economics
- Use as a base for delivery of all information
- Set up as a demo on farm for several years
- Define explicitly the questions producers are asking and build message around these questions
- Need improved information on options for chemical control - chemical use by prevailing conditions (reinforce 'do nots' with chemical given age of fireweed cohorts etc)

**c) Usefulness and Likelihood of "use" by participants: 3-4 / 5**

**3) CASE STUDIES OF SUCCESSFUL CONTROL – USING CHEMICAL, SHEEP OR GOATS, OR ANY OTHER CONTROL METHOD**

Detailed surveying of landholders who have successfully integrated sheep and goats into their cattle enterprises is required – based on production systems, including issues related to production, marketing, animal health, and enterprise (flock and herd) management. Costs and returns as well as documenting "pros and cons', of each approach should be included.

**a) Relevance of the proposed action for success in management - High / Medium**

**b) Suggestions for improvement:**

- Focus on success and make it relevant to people who are ‘giving up’.
- Include small blockies as a focal group – different drivers as have different outcomes (appearance of land vs. profit as a driver) – target this group
- Varied examples are required (sheep, goats, etc)
- Ensure they are timely and relevant to the broader community
- Economics is important
- Describe what doesn’t work as well as what works
- Emphasise control is not a “once a year action”
- Describe, “Before, What was done, After”
- Provide the ”economics of doing nothing” – cost of chemical means no fertiliser – where do you best place the input dollar?
- Provide commentary to illicit the ‘Guiding principles”. E.g - “ The most impacting factor in this case study was that they did X when the plants were…”
- Identify critical control points related to the actions (develop from Guiding principles)
- Must build a pathway of information – eg is the story is on goats, then signpost to get more info on goat management, where to source etc. Involve DPI NSW here.

**c) Usefulness and Likelihood of “use” by participants: 4/5 Helpful Frequent use**

**4) PAIRED PADDOCK DEMONSTRATION OF CONTROL USING SHEEP / GOATS**

**a) Relevance of the proposed action for success in management - Medium**

**b) Suggestions for improvement:**

- Rather than paired paddocks use landholders and discussion groups about the ‘whole farm management’ that involves tactical use of sheep or goats
- Need an associated experiment to generate data (thresholds for control, impact of density of pasture growth, and so animal production)
- Build a learning process around landholder farm visits that involve sheep and goats
- Need an answer to the question: Do sheep reduce FW populations or just reduce flowering (which should over time reduce populations)?
- Enable a forum to share experiences with other stock types
- Support the sheep/ goat story with management of sheep / goats – i.e anticipate the producers next question and have associated information available (type of stock, sourcing, duration required, market, trade of breed, associated stock issues)
- Must address sheep and goat management. Remove complexity and issues; highlight “best bet” options (to reduce complexity of breeding, wool production, health issues worms, etc)

**c) Usefulness and Likelihood of “use” by participants: 4**

**5) REGULAR FIELD DAYS OR FARM WALKS INVOLVING EXPERTS IN SHEEP AND GOAT HUSBANDRY**

Develop producer skills, knowledge and confidence in sheep and /or goat production. Coincide with the times when husbandry actions, need to be undertaken. The form of these days could involve presentation and discussion of issues; followed by a farm walk for hands- on demonstration, or inspection of, for example, workable make-do shearing sheds, fencing options etc.

**a) Relevance of the proposed action for success in management - High**

See item above. Focus on sharing experiences at farm walks , covering stock management as well as broader integrated / other measures progressed.

**b) Suggestions for improvement:**

- See notes above; establish a learning process with field days, small plot work, producers sharing their story. The regular field days with the experts on a range of topics was seen as highly useful
- Identify a series of properties – suggestion there are 75- 85 properties with sheep already
- Focus on addressing barriers to sheep and goats – focus is on sheep and goats to manage fireweed as against sheep and goat product.
- Emphasise reduction in costs (i.e. chemical saving) by animals stopping flowering should be presented as a positive for the animal gross margin
- Need to quantify impact of cessation of flowering on soil see reserves (could be a monitoring site, annual soil cores and see counts)

**c) Usefulness and Likelihood of “use” by participants: 5 Often, very useful**

## 6) DEVELOPMENT OF A "WHEN TO SPRAY GUIDE"

**Appendix 2 A Pictorial *when to spray* guide**

Figure 1. Germinating 1st cohort – too early to spray.

Figure 2. 1st cohort at 4-leaf stage; 2nd cohort germinating – earliest time to spray.

Figure 20. Plants 2-3 weeks old, growing vigorously; temperatures falling below 20°C; clover at th leaf stage. This is the optimum time to spray with Jaguar.

Figure 21. After plants flower, it is too late to spray with anything.

### a) Relevance of the proposed action for success in management - High

### b) Suggestions for improvement:

- Emphasis must be on plant growth to drive spraying and this will change between seasons. So the supporting management information must provide for several seasonal conditions (eg early rains, v late opening). Relate / context all statements to the opening rains
- Media can be used when opening rains as a trigger to determine the annual management action plan - early alert for recommended actions – i.e. ensures all messages are common
- Incorporate diagrams with the annual calendar tool
- A Fireweed identify Guide is needed. See the "Weed Deck" example http://www.sainty.com.au/weedeckpg1/weedeckpg1.html Fireweed is already on the Weedeck list Code number H009
- Laminated sheets are needed.
- Identify and prioritise actions for autumn based on fireweed prescience/dominance the previous spring.
- Support with an information sheet – chemical options; when to use; price of application
- Link penalty information with management recommendation. Bring the actions of regulatory and advisers together – "opportunity for control, be aware these are the issues". That is, incorporate legal with management

- Include a monitoring tool / process –what to look for in determining success and replanning subsequent activities. Focus on success - not just to "have sprayed", but "stop flowering"
- Need to define 'ho many plants / $m^2$ before impacts pasture or animal productivity"

**c) Usefulness and Likelihood of "use" by participants: 5 – Very useful**

## 7) MANAGEMENT STRATEGY DECISION TOOLS

A series of additional products/ tools were listed (see pre- meeting notes). A summary of discussion follows.

**i) deciding on particular strategies**.

- Determining paddock thresholds will also be influenced by a personal values / outcomes. Weed management should be promoted with the outcome being improved pasture and animal productivity
- Start with "20 plants / $m^2$" as a basis to define which paddock first
- A Trigger for action may be 5 plants / $m^2$

**i) deciding the time to act, and the timing of the actions**.

- Require some form of prompt/ reminder - call to action – media can assist here supported with recommended actions
- Prioritising and Monitoring tools would be helpful – but start with their definition of success. Main action should be a prompt to act, and where to act first
- An emphasis in Spring is required to set up the management plan for the following year

iii) **to monitor and analyse outcomes.**

- Encourage photo reference points – use a digital camera to capture change over time
- Broadbased media required in spring to start the planning process
- "Yellowness" in spring is a good indicator of need for action

## 8) DEVELOPMENT OF BEST MANAGEMENT GUIDES – INFORMATIVE AND INSTRUCTIVE

Guides to be developed within the context of local weed management control plans

- Must have a consistent message from all sources. Regulatory obligations must be married with an effective management plan.
- This is for blockies as well as larger landholders
- A BMP is needed, but a lack of underpinning information was identified.

***Local weed management plans need to be developed into user-friendly 'handy' documents. These need to:***

- Clearly state the obligations of the various parties to the plan;
- They should not contain aspirational, 'wooly' or impractical strategies or goals;
- Focus strictly on what can be done within the boundaries of the farm;
- State what the recommended practices are; and,
- Detail the success criteria.

**OTHER RECOMMENDATIONS IN THE REPORT NOT DIRECTLY ASSOCIATED WITH DELIVERY OF INFORMATION**, rather collection of data to understand the problem.

- A monitoring experiment is required (determine thresholds for actions, and to underpin a BMP)
- Require data on impact of fireweed on pasture productivity.
- From that will be able to consider pasture composition impacts and stocking rate issues.

## SUMMARY OF MAIN ACTIONS

- A technical workshop is required to review chemicals available, and appropriate application rates/ timing
- Information of chemical control required for advisors – what to spray, when. If season changes, so to may chemical options. Require uniform understanding
- A learning process is needed to be developed that includes broad based media to trigger awareness to act; demonstrations (chemical x timing); supported by weed id guide; when to spray guide; seasonal management calendar; chemical recommendations; demo/ research site (as suggested) visits; coupled with case study examples; discussion groups on case study farms considering role of various tools/ tactics

### Product Development

1) Seasonal management plan is a high priority need based on plant growth and recognising that seasonal actions (including chemical use), will change depending on the opening rains and infestation. This includes what "not to do"
2) Weed identity guide is a priority, and
3) When to spray – incorporate into the seasonal management tool
4) Case studies of various management actions – especially combination of tactics "Before situation; What was done; Results" to be developed

### Delivery process

- Demonstrations of "chemicals x timing" is a high priority, and how depending on how the season starts, will determine appropriateness of the chemical type

- Build a learning process around landholder farm visits – focus in options not, just on sheep or goats, but where did chemical fit, dollars in fencing or fertiliser or chemical etc .
- Farm walks and discussion important. Ensure have appropriate broad based technically competent people
- Use broadbased media and common communications (messages) from all sectors - “Look in October to drive next March actions” is a key message

**Notes**

- Use case study farmers to tell their story in discussion groups. Regular field days (accessed / promoted by different organisations) was seen as very positive. Development of a learning process was important, so need to look at the next question and have a signpost on a range of topics (animals, chemical, agronomy)
- Any action that gets people aware is positive
- Spring is the ultimate measure to trigger required actions the following year. Start the process then.

**Other points**

- Develop Critical Control Points for management. Use these as a basis for local media alerts, that can be tailored to the season. “Now is the time to…”
- Determine the questions producers are asking and shape delivery to address these (“eg if the season is late do I spray with…. ?”)
- Provide insights into where spend funds - cost of chemical may mean no fertiliser – where do you best place the input dollar ?
- There is a need for benchmarks/ thresholds. Need to define ‘how many plants / $m^2$ before impacts pasture or animal productivity”. A suggestion was provided of 20 plants as a baseline is when fireweed is an issue.
- Link with LGA actions and timing of delivery of notes for control and need for / requirements for monitoring populations
- A concise document is required by regulatory authorities for management actions that will meet the their regulatory needs – incorporate legal with management
- A “BMP advisors kit” is required
- A “BMP for blockies kit” is required
- Need to develop a flow diagram to understand what needs to be done first so can address gaps and build the BMP