Fireweed control research (DAFF 179/10)

Final report: fireweed ecology and impact study

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December, 2012

Acknowledgements

We are grateful for the advice and support provided by the Fireweed control research steering committee throughout the course of this project: Barry Powells (Coffs Harbour City Council), Bill Palmer (Qld DEEDI), Clare Edwards and Craig Muir (NSW DPI), Rowley Beckett (Dorrigo Community Weed Action), Bertie Hennecke (DAFF), and Noel Watson (Bega Valley Fireweed Association).

We appreciate the assistance of the farmers in the Dorrigo district who kindly allowed us to set up and monitor ecology and impact field sites on their properties.

We thank all farmers who gave their time and insight into fireweed by responding to the survey. Thank you to those who helped distribute the survey on our behalf, including Liz Gould (SEQ Catchments), Stacey Wellington and Ruth Chalk (Queensland Dairyfarmers' Organisation), Cameron Clarke (NSW Farmers' Association), Hayden Kingston and Peter Beale (NSW DPI), Wendy Bushell (Greater Taree City Council), Alison Rodway (Far South Coast Landcare), Peter O'Malley (Hawkesbury-Nepean CMA), Alexandra Kennedy (Condamine Alliance), Sue Dillon (AgForce Qld), and Sue Haslingden.

We appreciate the support of local interest groups in promoting this research and assisting with the survey, including the Bega Valley Fireweed Association, Dorrigo Community Weed Action, and the Kangaroo Valley fireweed group.

Finally, we would like to gratefully acknowledge the Australian Government, for funding this research through the Department of Agriculture, Fisheries and Forestry (DAFF). We particularly appreciate the support of Peter Langdon from DAFF over the course of the research.

Executive Summary

This report details the results of a fireweed ecology and impact field study in Armidale and Dorrigo, NSW, and a national survey of landholders to evaluate fireweed impact and management.

Ecology and impact field study

The goals of the field study were to assess the impact of fireweed on pasture biomass production and availability, examine seasonal fireweed emergence patterns in the presence and absence of pasture competition, and assess the longevity of fireweed seeds in the soil at different burial depths and locations.

The pasture impact and fireweed emergence field trials were conducted at two sites near Dorrigo. The seed longevity trial was conducted in two locations, one of the field sites near Dorrigo and a second site at Armidale.

Where fireweed cover was high in grazed areas, pasture biomass was considerably higher than in areas where fireweed was scattered, suggesting that the pasture was not being grazed by livestock in heavy infestations, and was therefore unavailable to them. Variability in the data though meant that this was not a statistically significant result, and requires follow-up research. Once grazing was removed, it appeared that while fireweed cover always had a significant influence on pasture biomass, the influence in this one season in a kikuyu based pasture was negligible, with less than 1% of the change in pasture biomass being accounted for by fireweed cover. But again, due to the short term nature of the trial, and the lack of fireweed growth during a large part of the experiment, it was difficult to measure true treatment differences.

Recommendation

Further research is required across a range of pasture types, climatic environments, soil types and seasons to assess the competitive impact of fireweed on pasture production. Equally important is the need to identify threshold values of fireweed densities above which fireweed reduces the availability of pasture to grazing animals due to their dislike of grazing amongst these unpalatable plants.

The study of seasonal emergence patterns for fireweed showed that the peak germination period in 2011 from March to May on the Dorrigo plateau was consistent with previous data from the County of Cumberland. Knowing this should help landholders with the timely application of control practices.

Baring of soil by removal of pasture competition through regular application of herbicide lead to greater emergence of fireweed than in pasture covered experimental plots. This result reiterates the need for strong pasture competition as a key ingredient of long-term fireweed control.

Recommendation

Research is needed on the effectiveness of herbicides on seed mortality, including herbicide timing (direct to the soil and to the plants at various stages of growth), and the effectiveness of wick wiping for fireweed control.

The seed longevity trial is continuing so that we can obtain long-term data on fireweed seed survival. However, over the first 12 months of burial important trends have become apparent. Like many other species, seed of fireweed appears to survive in a viable condition for longer when buried, and more so at greater depths, at least down to 10 cm, where after 12 months of burial about 30% of seeds remained viable across both sites.

On the soil surface, however, where it is expected that most fireweed seed would be present after being shed from the parent plant in most uncultivated field situations, most seed germinated within the first 3 months. Consequently, after 12 months only a few per cent of seed remained ungerminated and viable. These data suggest that in these relatively high rainfall environments the soil seed bank of fireweed may decline quite rapidly. Where fireweed seed can be prevented from reinfesting a paddock over a 12 to 18 month period, infestations of above ground populations are also likely to decline significantly.

Recommendation

The data from the seed burial trials conducted for this research should be augmented with seed bank population data from naturally occurring field infestations to be sure that the results of this research are not an artefact of artificial burial procedures.

Survey of landholders

Many of the questions in the questionnaire repeated an earlier survey conducted in 1985 to identify changes in fireweed impact and management over time, and to assess current impact and management issues at a regional level.

Fireweed has continued to spread into new regions. It is a relatively recent arrival in the NSW Northern and Southern Tablelands, parts of the NSW Mid-North Coast, and South-East Qld. Severe infestations have become more common in Bega, Shoalhaven, Lismore, NSW Mid-North Coast and South-East Qld. It has been present for longer in parts of the NSW far north coast, around Port Macquarie and Wauchope, the Gloucester/Taree region, the lower Hunter Valley, and the south-west fringe of Sydney.

Wind-blown seed was considered by survey respondents to be the most significant means of fireweed spread, followed by birds and other animals, and vehicles and machinery contaminated with seed.

Recommendation

Further research is needed to understand vectors of spread for fireweed, particularly dispersal via birds and wind-borne seed. The potential for birds to spread fireweed is currently unknown.

Fireweed was less likely to be considered a major problem in areas where it has spread recently, or in areas where it had occurred for the longest. Those from the former may not yet be fully impacted by fireweed, while those from the latter may have learnt over time to live with/manage the weed more effectively. Similarly, those who had fireweed on their property for less time were less likely to consider fireweed a major problem than those who had it for longer.

The factors considered most likely to contribute to bad fireweed years include poor fireweed control by neighbours, lack of time/labour/money to control fireweed effectively, and rainfall following drought.

Recommendation

Further research is needed to more specifically identify the particular climatic factors that contribute to 'bad' fireweed years so that landholders can better prepare fireweed management strategies.

Fireweed was the worst weed for about a third of respondents. It was more likely to be considered the worst weed in Bega, Shoalhaven, Hexham and the Mid-North Coast, and least likely in Muswellbrook and Gloucester.

Bare ground and heavily grazed pasture appear to be the most significant situations favouring the growth of fireweed, though there is a perception that fireweed is capable of growing at problematic levels regardless of the soil/pasture circumstances.

Both dairy and beef producers were significantly more likely to have large or moderate fireweed infestations on their property than sheep producers, and similarly were more likely to perceive fireweed as a moderate or major problem, reflecting perhaps the ability of sheep to manage fireweed, and the location of sheep properties further away from the coast where fireweed is less dominant.

Since 1985, fireweed management practices have changed. Slashing and cultivation are less likely to be used, while the use of herbicides and grazing with sheep or goats appears to have increased.

Of the fireweed control methods available, hand weeding remained the most common and one of the most effective control methods according to respondents, though it was very time-consuming, labour-intensive and physically demanding.

Slashing and cultivation had declined in popularity since 1985, though slashing remained a relatively popular method. Slashing was considered to have a number of potential drawbacks, with many respondents suggesting it makes the problem worse, presumably because of the spread of seed.

The proportion of farmers controlling fireweed with herbicide appeared to have increased significantly, particularly in the Cumberland, Mid-North Coast, South-East Qld, and Shoalhaven regions. However, some survey respondents suggested that herbicide created ongoing fireweed control problems, as it created bare ground on which fireweed reinfestation could easily occur.

Promoting competitive pasture should give farmers ongoing fireweed control benefits, particularly as it was noted in this survey that overgrazing and bare ground favour fireweed establishment and contribute significantly to 'bad' fireweed years. Overall, kikuyu was considered to be the best species for fireweed control, followed by ryegrass, paspalum, and white clover, though this varied between regions depending on what pasture species have been trialed and are best adapted in a particular region.

Grazing with sheep or goats was considered to be the most successful fireweed control method overall. However, just over 10 per cent of respondents used sheep or goats to graze fireweed on their property. Sheep or goat producers spent significantly less time and money on fireweed control, and sheep producers were less likely to consider fireweed to have an impact on farm profitability. Importantly, however, establishing sheep or goats on a cattle property can impose a large cost on farmers in terms of farm infrastructure.

Considerable success with fireweed control can be achieved through an integrated approach that may incorporate encouraging strong competitive pastures, hand weeding, herbicide control, and grazing with sheep or goats. Those who had success reducing the extent of fireweed on their property were most likely to credit their success to dedicated use of one, or a mixture, of these approaches.

Recommendation

Extension is required to ensure farmers are aware of correct herbicide use for fireweed control. Landholders also need to be made aware of other successful methods to manage fireweed on their land, particularly pasture improvement and grazing with sheep or goats. Hand weeding was also popular, particularly for smaller infestations. There is potential to increase the number of landholders using these methods as part of an integrated strategy, particularly landholders who currently show little interest in controlling fireweed.

Nearly half of respondents estimated that they spent over 50 hours each year controlling fireweed on their property, while nearly 40 per cent estimated they spent $1,000 or more on control activity. Fireweed control appeared to be more time consuming and expensive for residents in Hexham, Bega, Shoalhaven and the Mid-North Coast. Of those who consider fireweed to be under control on their property, approximately 50 per cent spend more than 50 hours and more than $1,000 per year on control activity. This suggests that maintaining fireweed at a controllable level on farm can be a significant ongoing cost to farmers in time and money.

Recommendation

A case study approach may be useful in quantifying the cost of fireweed control activities on farm. Options include exploring the cost for different types of production, different regions, and on farms which experience low and high levels of infestation. It may also be helpful to quantify the cost of different weed control methods (such as herbicide and sheep/goat grazing) to help farmers decide on the relative merits of different methods.

Over 62 per cent of respondents believe fireweed should be declared noxious or prohibited under legislation. For those who agreed with declaration or prohibition, the largest proportions considered that it was required to force neighbours to control the weed, and that enforcement was a necessary part of the overall strategy to deal with the significant threat fireweed posed to agricultural production. Those not in favour of declaration or prohibition, however, were likely to consider it counter-productive, as the weed was seen as too difficult to manage. Similarly, it was viewed as imposing an impossible legal obligation on many farmers.

Recommendation

Noxious weed regulation may need to be strengthened as part of an overall approach to restricting fireweed spread. However the focus should be on regions where fireweed is a more recent arrival and has a greater prospect of being managed, rather than in regions where the weed is an intractable problem for many farmers.

Farmers appeared to be relatively positive overall regarding the future control of fireweed using currently available control methods. Despite this, over half of respondents considered that a biological control option would be a 'very important' development in the fight against fireweed.

Recommendation

There is a strong interest and demand for ongoing research into potential biological control options amongst farmers impacted by fireweed. A high priority for research funding for fireweed as a WoNS should be to continue the biological control research in South Africa that commenced as part of this project.

The largest proportion of respondents indicated that they were unlikely to change their fireweed management approach in the next two years. Of those that were contemplating change, many considered implementing herbicide control, pasture improvement and sheep or goat grazing, which were also found to be amongst the most successful fireweed control methods.

The most significant economic impacts of fireweed on farmers included lack of time available to devote to other activities, and overall farm profitability. Fireweed control appeared to be particularly time consuming in the Shoalhaven, Bega and Mid-North Coast regions, and it was notable that these regions were amongst those where fireweed was considered by a higher proportion of survey respondents to be a moderate or major problem.

Recommendation

More detailed information is required to quantify the economic impact of fireweed on agricultural production, including identifying the practical level of tolerance farmers can assume for fireweed, benefit/cost analyses of its impact on pasture production, economic impact on a national scale, and impact on individual farmer livelihoods.

Amongst the most important social problems caused by fireweed was tension between neighbours, which appeared particularly relevant in the Bega and

Shoalhaven regions. Tension can arise due to neighbours who control fireweed poorly being considered a source of weeds by farmers who believed they were managing the weed well. Other important social issues included personal physical health issues resulting from fireweed presence, due to the effort required to control the weed and illness resulting from hand pulling without gloves. Mental health issues were also considered important.

Recommendation

Further research is also warranted regarding the social impacts of fireweed. Topics to explore include the strain fireweed imposes on farming families, conflict created between neighbours, and impacts on farmer health.

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1. Introduction

1.1. Background

Fireweed (*Senecio madagascariensis*) is one of the worst weeds of coastal pastures of southeastern Australia. It is highly invasive and contains toxic pyrrolizidine alkaloids that, if consumed, cause liver damage in livestock, reducing their growth and leading, in some cases, to death. The weed therefore causes considerable concern to farmers and rural communities in impacted areas.

Originating in south-eastern Africa, fireweed was introduced to the Hunter Valley in Australia around 1918 (probably through shipping) and has since spread north and south in coastal New South Wales and southern Queensland. It is now invading pastures on the Monaro and Northern Tablelands of New South Wales and Atherton Tablelands of far north Queensland.

A report for the Bega Valley Fireweed Association (Sindel 2009) identified a number of gaps in current knowledge about fireweed, including the need for comprehensive research into potential biological control agents for fireweed in its native South Africa, and understanding the ecology and impact of fireweed. In 2010 the Australian Government, through the National Weeds and Productivity Research Program, invested in a fireweed control research project to investigate these issues. The research was undertaken jointly by the University of New England (UNE) and CSIRO.

1.2. Objectives

1. Establish a community consultation Steering Committee at commencement of the project, to remain active until completion of the project.

> A Steering Committee comprising fireweed experts and landholders was established upon commencement of the project, and two meetings held in August 2010 and February 2012, with email communication in between times. The Steering Committee minutes were published on the project web site.

2. Produce a report on fireweed against the Australian Weeds Committee (AWC) assessment criteria for the WoNS nomination process.

> A submission to have fireweed declared a WoNS was delivered to DAFF and then the AWC in September, 2010.
>
> Fireweed was one of 12 weed species added to the WoNS list in April, 2012.

3. Produce a final report synthesising existing research and new practical research into fireweed ecology and impacts on agricultural productivity and biodiversity in Australia.

The ecology and impact study involved field trials in Armidale and Dorrigo, NSW, and a national survey of landholders. The results are presented in Chapters 2 and 3 of this report. A copy of the survey questionnaire is included as Attachment 1.

4. Produce a final report on investigation of potential biological control agents in South Africa, including the KwaZulu-Natal province and surrounding areas.

The biological control research was conducted by the University of KwaZulu-Natal (UKZN), under sub-contract to CSIRO. Research progress is detailed in a separate report.

5. Produce a communication plan to keep industry and community groups informed of research aims and progress, and to help translate research findings into practical tools.

A draft communication plan was delivered to DAFF in October, 2010, and a communication update delivered in May, 2011.

At the time of project completion, research staff had gathered approximately 550 email addresses in a communications list, and a number of media articles had been published in local and national media about the project.

The communications list was used to distribute copies of the updated best practice management guide (see below).

A presentation on the research was made at the 18th Australasian Weeds Conference in October, 2012, and a refereed paper published in the conference proceedings. An academic journal paper is being prepared for publication.

6. Produce a national best practice management manual for fireweed of approximately 32 pages in hard copy and DVD.

A draft best practice management manual of 40 pages was prepared in December 2011, delivered to DAFF, and published on the project web site for comment.

A final version of the guide was published in hard copy in mid-2012, and included on the project web site. Hard copies were distributed to contacts on the communications list, with remaining stock distributed on a first-come first-served basis. All 3,000 printed copies were distributed within three months of publication. A copy is included with this report (Attachment 2).

It is likely that the current guide will be expanded into a national best practice manual for fireweed as part of the WoNS process.

2. Ecology and impact field study

2.1. Research aims

1. To assess the impact of fireweed on pasture biomass production and availability;
2. To examine the seasonal emergence patterns of fireweed in the presence and absence of pasture competition;
3. To assess the longevity of fireweed seeds in the soil at different burial depths and locations.

2.2. Methods

2.2.1. Pasture impact and fireweed emergence field trial

The first field trial in which we assessed both fireweed impact on pasture production and fireweed seedling emergence times was conducted at two sites on the mid-north coast west of Dorrigo NSW (Jack's and Allan's). Dorrigo has an average annual rainfall of 2068 mm, with 45% of the rain occurring between January to March (1997-2012). The average daily temperature range in Dorrigo (1997-2012) was 4.4˚C to 14.3˚C in July and 14.8˚C to 24.0˚C in January (Bureau of Meteorology 2012a). The two nearby sites were both on kikuyu-based pastures and were selected on the basis of accessibility and high fireweed populations.

At each site four cattle exclusion cages were erected (4.8 m long × 4.8 m wide × 1.2 m high). Within each cage three fireweed–pasture treatments were initially randomly assigned for the impact study based on the natural population density of fireweed; a 'high' fireweed ground cover (35–50%); a 'low' fireweed ground cover (15–35%); and a 'zero' fireweed ground cover (all plants removed at the commencement of the study).

A bare 'no-competition' plot (sprayed with Round-up every 3 months) was also located inside the cage (Figure 2.1) with an additional grazed treatment adjacent to the 'no-competition' plot outside the cage to monitor the emergence of plants with and without grazing, and signs of any grazing on such plants. Each treatment was contained in a 1 × 1-m plot with a buffer zone of > 90 cm between treatments or the edge of the cage (Figure 2.1).

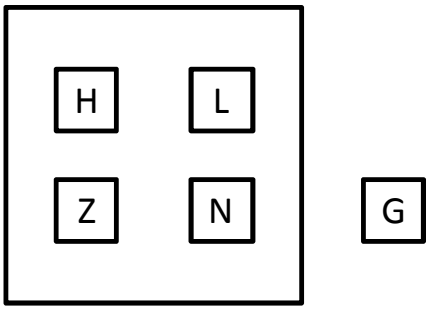

Figure 2.1: Schematic example (to-scale) of a stock exclusion cage layout (H = 'high' fireweed cover; L = 'low' fireweed cover; Z = 'zero' ground cover; N = 'no-competition'; and G = 'grazed' plot)

In the 'high' and 'low' treatments the percentage live and dead fireweed groundcover was estimated visually by two observers, and the mean taken. In addition, cover was measured by recording the average diameter of the width and length of each plant or clump of plants if the canopies of multiple plants were overlapping or touching one another. Leaving all fireweed plants in these two plots, all pasture biomass was then cut with mechanical shears to approximately 1 cm above ground-level (Figure 2.2). In the 'zero' treatment all fireweed plants were counted, cover estimated and removed from the plot before cutting all pasture biomass each sampling time.

Figure 2.2: Clipping pasture biomass in the treatment plots.

In the 'no-competition' treatment all fireweed plants were counted, cover estimated and removed. And in the 'grazed' treatment new plants are observed, tagged using a small 1 cm piece of clear tubbing, measured, the vegetative life stage recorded, and examined for any signs of grazing.

In each treatment if the stems of the fireweed plants were within the treatment boundary they were included in the experiment, however their cover was only estimated to the edge of the plot.

Sampling of all plots for both fireweed impact and emergence was repeated approximately every 30 days from 27th October 2010 to 5th February 2012 (n = 15). Each pasture sample was air-dried and weighed to determine pasture productivity in each fireweed–infested treatment.

2.2.2. Seed longevity trial

The seed longevity trial was conducted in two locations; on one site at Dorrigo and in another site on the Northern Tablelands of NSW at Armidale. Around Armidale rainfall also tends to summer dominance with an average annual rainfall of 818 mm (1994-2012). The average daily temperature range in Armidale (1997-2012) was 1.1˚C to 12.0˚C in July and 13.1˚C to 25.8˚C in January (Bureau of Meteorology 2012b). Frosts are common from mid April to September (Lodge and Whalley 1989).

Approximately 20 000 fireweed seeds were collected from each Dorrigo site in October 2010. In an incubation cabinet, set to 25/15°C day/night with a 12/12 hour day/night, in four petri dishes per site, 25 seeds were placed (100 seeds / site) on a moist filter paper (watered using distilled water). Ensuring the filter paper remained moist, seed germination was recorded every second day for two weeks, removing seeds from the petri dish once germinated. This pilot study demonstrated that germinable seed differed between the sites (70% germinated and 85% germinated, respectively), and therefore only seeds from the site with the higher germination level were used in the seed longevity trial. In a fine mesh bag 50 seeds from this site were combined with 50 g of sterile soil (sterilized using an autoclave for 35 minutes) from the same site. To maximise the number of viable seeds, prior to adding the seeds each individual seed was examined under a 5x microscope to ensure that it appeared 'plump' or viable at time zero. This procedure was repeated for all 240 seed bags.

In a fifth livestock exclusion cage at the same site at Dorrigo, four replicates were set-up. Each replicate contained 10 bags on the soil surface, 10 bags buried at 2 cm deep and 10 bags buried at 10 cm deep. There were to be 10 exhumation dates. This same layout was repeated in a paddock in Armidale, NSW. The trial commenced on the 26th November 2010 in Dorrigo and on the 3rd December 2010 in Armidale, although one month prior to commencing the trial the cage was sprayed with Round-up to remove surface vegetation. To maintain a relatively barren ground cover the plots were sprayed every three months with Round-up (the surface bags were covered prior to spraying). At approximately time 0, 1 month, 3 months, 6 months and 12 months post start date one randomly selected bag from each depth in each replicate at each site was removed. To ensure that the bags remained in each site for the same number of days the bags in the Armidale site were always removed 7 days after the bags in the Dorrigo site to reflect the one week delay in commencing the experiment at this site.

At the time of exhumation the mesh bags were air-dried, all soil and seeds carefully removed from the bag using a toothbrush, shaken through a series of progressively smaller sieves and all fireweed seeds were manually extracted from the soil using tweezers. The search time was limited to approximately one

hour per bag, which reflected sufficient time to find all seeds remaining in the bag. Seven days after the bags were extracted from the plots the seeds from each bag were placed on moist filler paper (watered using distilled water) in a petri dish in an incubation cabinet, set to 25/15°C day/night with a 12/12 hour day/night. Ensuring the filter paper remained moist, seed germination was recorded every second day for two weeks, removing seeds from the petri dish once germinated. After the two week incubation all remaining seeds were placed in a tetrazolium solution (1%) for 24 hours in a dark cool cupboard to assess their viability. Due to their small size, seeds were not bisected prior to being added to the tetrazolium. After 24 hours each individual seed was examined under a 5x microscope and categorised as either a) embryo viable (stained bright pink), b) embryo non-viable (remains white or clear), or c) an empty seed casing.

At each time of exhumation fireweed seeds were classified as either: 1) Germinated – all seeds that could not be found in the mesh bags of the original 50, or where there were empty casings, were assumed to have already germinated prior to exhumation; 2) Viable – germinated seeds from the incubation plus the stained seeds were together assumed to be the remaining viable seeds; and 3) Non-viable seeds – remaining seeds not stained pink.

2.2.3. Statistical approach

All data were analysed in SPSS V17.0 (SPSS Inc. 2010). Prior to analysis all data were checked for homogeneity using the skewness value divided by the associated standard error (which equates to the z-score) and ensuring the resultant does not exceed the absolute value of 2.58 for a sample size of less than 300 or an absolute value of 3.29 for a sample size of greater than 300 (Tabachnick and Fidell 1996). Where this assumption was violated the data were appropriately transformed or if they were unable to be transformed an appropriate non-parametric test was used.

A Hierarchical Multiple Linear Regression was employed by first removing the potential effect of site to determine the influence of fireweed cover on pasture biomass in the presence of grazing. This could be completed using the time zero data only from the high, low and zero fireweed cover treatments, and essentially gave a measure of pasture availability to livestock at this first sampling. There was more ungrazed pasture growing amongst high levels of fireweed than at low or zero fireweed levels. After this first sampling, plots were no longer grazed.

To assess the affect of fireweed cover on pasture production at these subsequent samplings, a Hierarchical Multiple Linear Regression was employed on the 'high', 'low' and 'zero' fireweed plots, by first removing the effect of sampling time and then the effect of site before including fireweed cover in the regression model. This was repeated using live and total fireweed cover as visually estimated and total fireweed cover as measured to examine if there was any difference in the outcomes.

Since the data for examining the seasonal emergence patterns of fireweed could not be normalised, a Kruskal-Wallis test was conducted with Month as the

dependent variable and Number of Plants emerged in the 'zero' treatment plot as the dependent variable. A Mann-Whitney test with a Bonferroni adjustment was then used to assess the statistical differences. A Mann-Whitney test was also conducted with Plot Treatment as the independent variable and Number of Plants emerged in the 'zero' or the 'no-competition' treatments as the dependent variable to assess the influence of herbicide application. Due to the nature of this test the changes in emergence over time could not be statistically analysed, but only between the treatments within an individual site.

Lastly, for the seed longevity trial a three way repeated measures analysis of variance was conducted examining the number of germinated seeds, or the number of remaining viable seeds or the number of non-viable seeds, as the dependent variable measured at two locations (Dorrigo, Armidale), three depths (surface, 2 cm, 10 cm) and over five exhumation times (0 months, 1 month, 3 months, 6 months, 12 months). As the variance F-max was higher than the critical value of 3 we could not assume the variances were equal and therefore a stricter probability value of 0.1 was used to assess significance.

2.3. Results and discussion

2.3.1. The effect of fireweed cover on pasture biomass in the presence of grazing

The analysis of pasture biomass at time zero under grazing demonstrated that Site had no influence on the result (R= .014, R^2= .000, $F_{inc}(1,22) = 0.04$, $p > 0.05$) and thus could be treated as replicates. Figure 2.3 indicates that where fireweed cover was high (as visually observed) pasture biomass was higher, but because of high variability in the data this was not a significant result (R= .355, R^2= .126, $R^2_{change} = 0.126$, $F_{inc}(1,21) = 3.022$, $p > 0.05$). It remains to be determined through further experimentation beyond this one set of data points whether fireweed at high densities does significantly reduce availability of pasture growing amongst it to livestock.

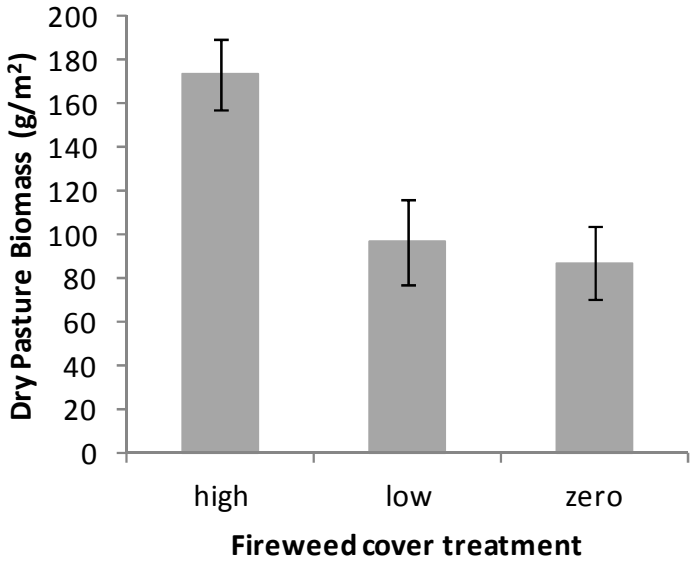

Figure 2.3: Dry pasture biomass in each fireweed cover treatment in the presence of grazing at Time 0 ± 1 SE (n=8).

2.3.2. The effect of fireweed cover on pasture biomass without grazing

Hierarchical Multiple Linear Regression was employed to establish whether the addition of Site and Sampling Time provided improvement in the prediction of pasture biomass over that provided by Live fireweed cover (as visually observed), Total fireweed cover (as visually observed) or Total fireweed cover (as measured) alone. Regardless of how fireweed cover was measured (live or total, or visually or measured) Sampling Time was found to be a significant predictor of pasture biomass, whereas the addition of Site resulted in no significant improvement in the prediction (Table 2.1). Between 11 and 15% of the variation in pasture biomass was explained by the full set of independent variables (Table 2.1 and Figure 2.4). However, the actual cover of fireweed measured only accounted for between 0.5 and 0.7% of the variation in pasture biomass (R^2change = 0.049 to 0.071) (Table 2.1). The prediction equation with the highest percentage of variability accounted for describes the relationship between the variables to be:

Pasture Biomass = 0.536 x Total fireweed cover (as measured) + 0.092 x Number of sites examined - 0.165 x Number of Months Observed + 8.779

Therefore, whilst fireweed cover (whether it was live fireweed cover only, or total fireweed cover as visually observed or measured) always had a significant influence on pasture biomass, the influence was negligible (Figure 2.5), with less than 1% of the change in pasture biomass being accounted for by fireweed cover.

However, this trial has confirmed that it is very difficult to assess the impact of fireweed on pasture production in detail over only one season of fireweed growth. Due to the logistics of setting up the exclusion cages only two sites could be used and unfortunately both of them were based on pastures of kikuyu, which is known to be one of the most competitive species against fireweed. This may be

one reason why fireweed had little impact on pasture production. Furthermore, when the trial was set up in October 2010 when there were high fireweed populations, the plants were near to the time of their peak growth (Figure 2.6). After this they were less likely to exert competitive pressure on the kikuyu. In the following spring there was unfortunately little fireweed germination in these experimental plots to be able to measure treatment effects over what should have been the active fireweed growing season (Figure 2.6 and Figure 2.7).

Further research is required across a range of pasture types, climatic environments, soil types and seasons to assess the competitive impact of fireweed on pasture production. However, it appears that with a competitive pasture grass like kikuyu in a high rainfall environment like Dorrigo, fireweed may have little impact on pasture growth. Equally important is the need to identify threshold values of fireweed densities above which fireweed reduces the availability of pasture to grazing animals due to their dislike of grazing amongst these unpalatable plants.

Table 2.1: Model summaries from Hierarchical Multiple Linear Regressions examining the effect of fireweed cover on pasture biomass

Model Predictors	Df	R	R^2	Adj R^2	R^2 change	F
Time	1,349	0.248	0.062	0.059	0.062	22.97***
Time+Site	1,348	0.249	0.062	0.056	0.000	0.01
Time+Site+Live fireweed (observed)	1,347	0.332	0.110	0.103	0.049	18.96***
Time	1,358	0.287	0.082	0.080	0.082	31.10***
Time+Site	1,357	0.287	0.082	0.077	0.000	0.03
Time+Site+total fireweed (observed)	1,356	0.380	0.144	0.137	0.062	25.66***
Time	1,373	0.284	0.081	0.078	0.081	32.75***
Time+Site	1,372	0.284	0.081	0.076	0.000	0.01
Time+Site+total fireweed (measured)	1,371	0.284	0.151	0.144	0.071	30.86***

*** $p < 0.001$

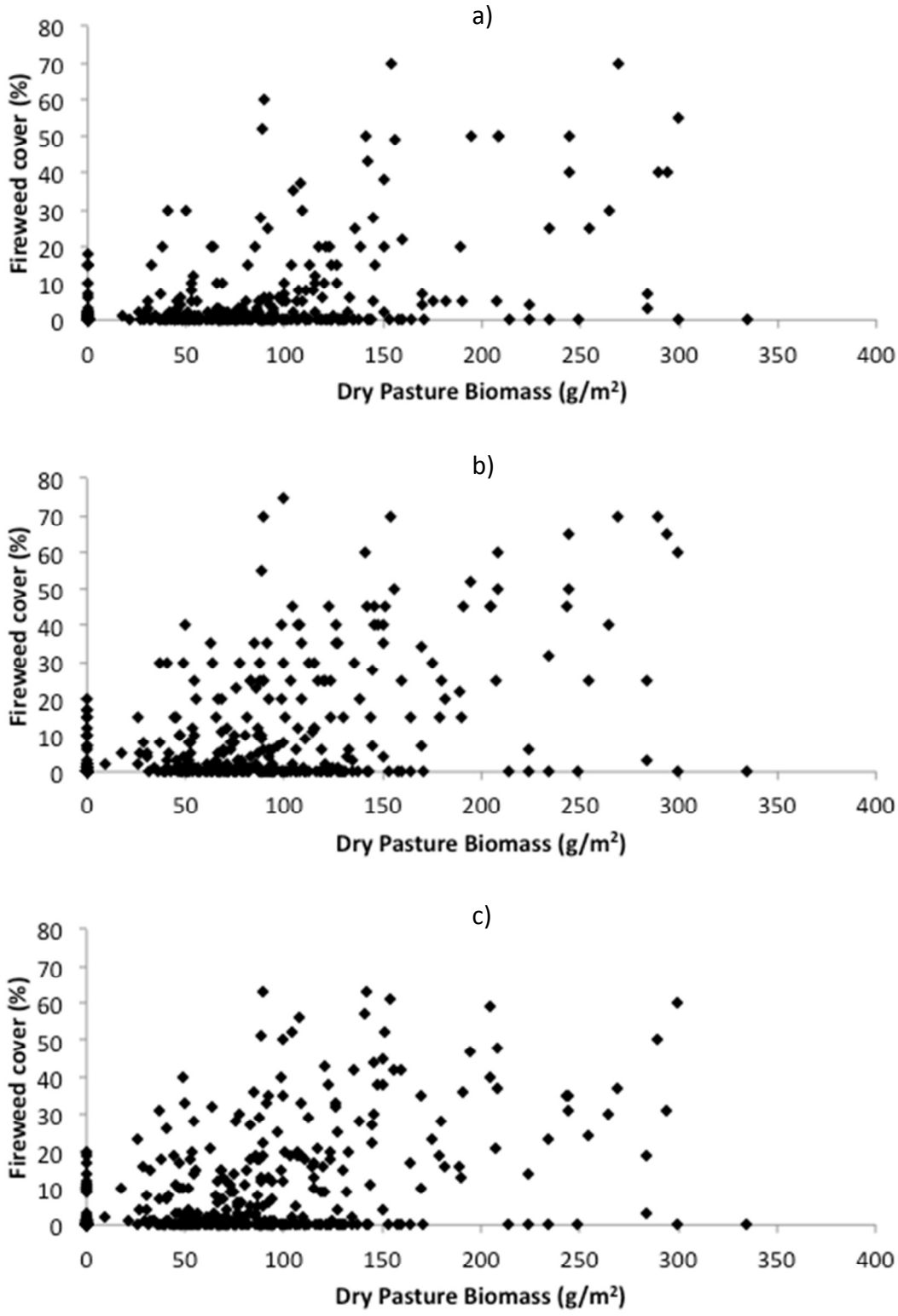

Figure 2.4: Dry pasture biomass against a) live fireweed (as visually estimated) b) total fireweed cover (as visually estimated) and c) total fireweed cover (as measured) throughout the experiment (n=120).

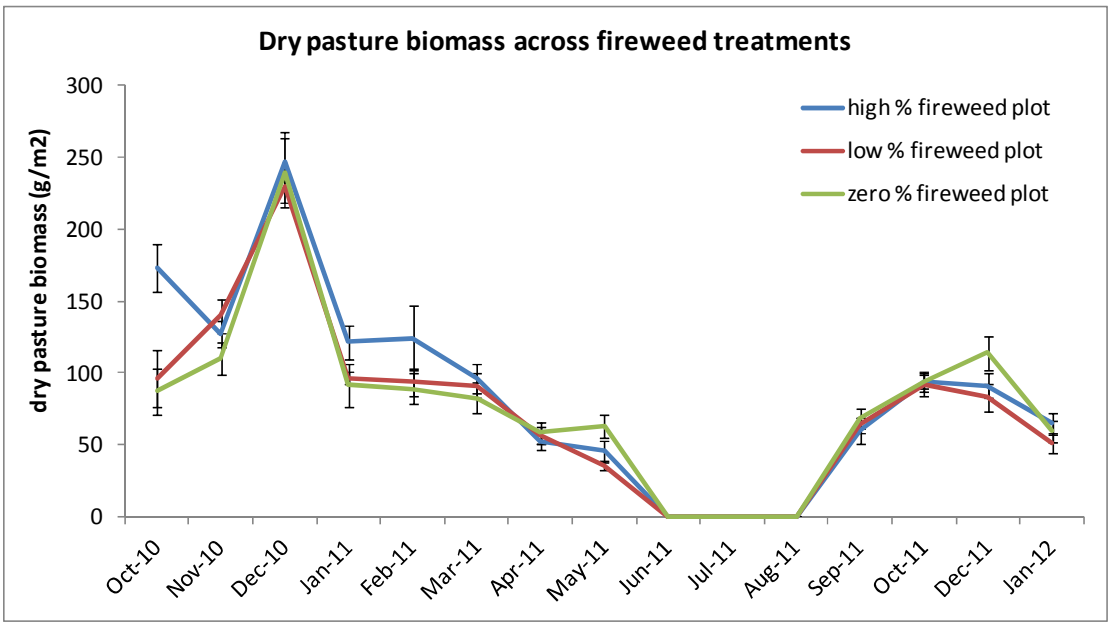

Figure 2.5: Dry pasture biomass across all fireweed treatments throughout the experiment (n=120). Vertical bars are one standard deviation.

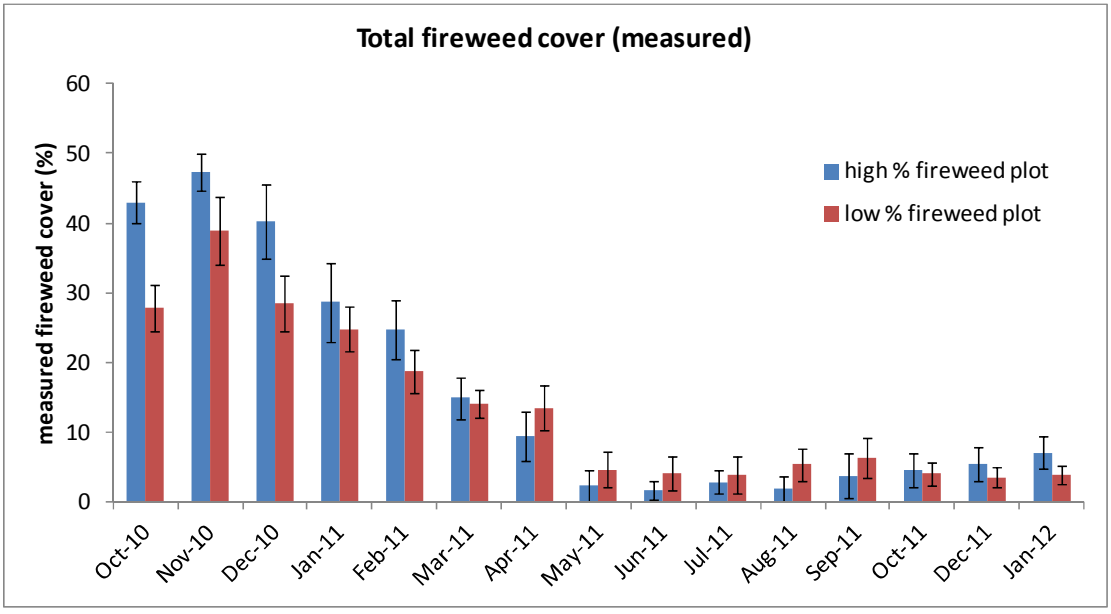

Figure 2.6: Measured total fireweed cover in high and low % plots. Vertical bars are one standard deviation.

Figure 2.7: Comparison in fireweed presence in a 'high' fireweed ground cover plot October 2010 and October 2011.

2.3.3. Seasonal emergence patterns of fireweed

A Kruskal-Wallis test indicated that the two sites did not significantly differ in regards to seasonal emergence of fireweed [$\chi 2$= (df = 1, n = 120) = 0.08, p > 0.05)] and could therefore be treated as replicates. A test was then conducted with Month as the dependent variable and Number of Plants emerged in the 'zero' treatment plot as the dependent variable. The 11 groups were found to differ significantly [$\chi 2$= (df = 10, n = 120) = 32.71, p < 0.001)]. Post-hoc test comparisons were conducted using Mann-Whitney U tests with a Bonferroni adjustment of alpha to α = 0.0009. The adjustment resulted in the month of April displaying a significantly higher median score (median=8) than the month of January (median= 0), U = 12.0, p < 0.0009. No other significant comparisons were found (Figure 2.8a).

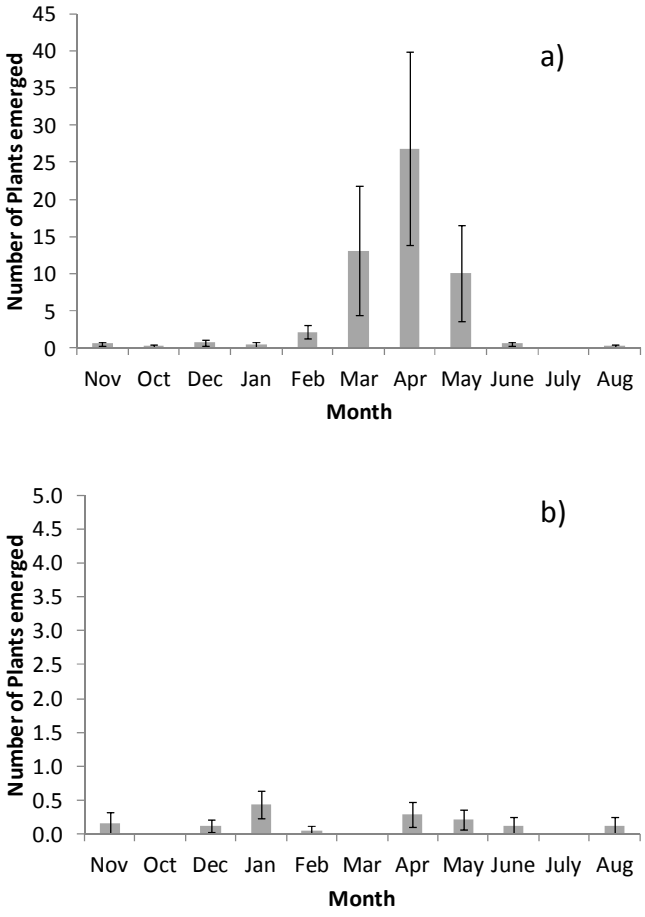

Figure 2.8: The mean number of plants emerged in each month examined in the project in the a) zero treatment plot and b) grazed treatment plot ± 1 SE (n=120 (a) and n = 128 (b)) (note the difference in scales).

In the grazed treatment neither Site nor Month was found to be significant [$\chi 2$= (df = 1, n = 128) = 0.111, $p > 0.05$) and $\chi 2$= (df = 10, n = 128) = 13.45, $p > 0.05$, respectively), and there was no peak in March, April and May as in the zero plot. One reason could be the fact that the grass was clipped consistently short in the zero treatment compared with the grazed treatment which, because of cattle grazing, was visually taller and had a greater volume and weight of grass.

Presumably the greater pasture biomass reduced fireweed seed germination, emergence and survival in the March to May peak period. It is also possible that any seedlings that may have germinated during this time were eaten during the grazing process. The peak germination period in 2011 from March to May on the Dorrigo plateau is consistent with previous data from the County of Cumberland. Knowing this should help landholders with the timely application of control practices.

2.3.4. Effect of repeated herbicide application on fireweed emergence

As the data could not be normalised a Mann-Whitney test was conducted with Site as the dependent variable and Number of Plants emerged in either the 'zero' or the 'no-competition' treatment plot as the dependent variable. Although the two sites were found not to differ significantly for the 'zero' plot [(U = 1994.5, df = 1,128, p > 0.05), they did for the 'no-competition' plot (U = 1202.5, df = 1,120, p < 0.01) and were therefore analysed separately. For each site a Mann-Whitney test was conducted with Plot Treatment as the independent variable and Number of Plants emerged in treatments as the dependent variable. At one site (Allan's) the number of plants to emerge over the course of the experiment did not differ between the zero treatment plot and the herbicide plot (U = 1789.0, df = 1,124, p > 0.05 – Figure 2.9). Whereas at the other site (Jack's), significantly more plants emerged in the plot sprayed with herbicide than the plot that was not over the course of the experiment (U = 1352.5, df = 1,124, p > 0.01 – Figure 2.9).

The data suggest that baring of the soil and complete removal of competition through regular application of herbicide is likely to lead to greater emergence of fireweed. This reiterates the need for strong pasture competition as a key ingredient of long-term fireweed control.

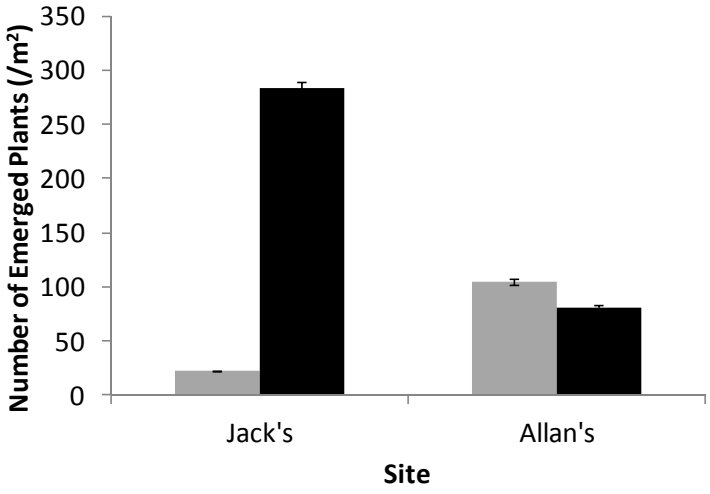

Figure 2.9: The mean total number of plants emerged in the 'zero' plot (grey) and the 'no-competition' plot (black) (per m²) examined throughout the project in each site ± 1 SE [n=64 (a) and n = 60 (b)]

Although it cannot be analysed statistically due to the heterogeneous nature of the data, Figure 2.10 shows the observed changes in emergence counts of fireweed plants between the sites and the 'zero' and 'no-competition' treatments over the course of the experiment. Herbicide application usually resulted in no fireweed emergence in the month directly following application. The highest emergence coincided in both treatments in March and April, while the application of herbicide in April in the 'no competition' plots appeared to suppress the expected emergence (based on the zero treatment) in May (Figure 2.10).

While these results are preliminary, further research is warranted on the effect of the herbicide glyphosate (Roundup) as well as other herbicides on the germination of fireweed seed, applied either to the soil or the plant at various stages of growth.

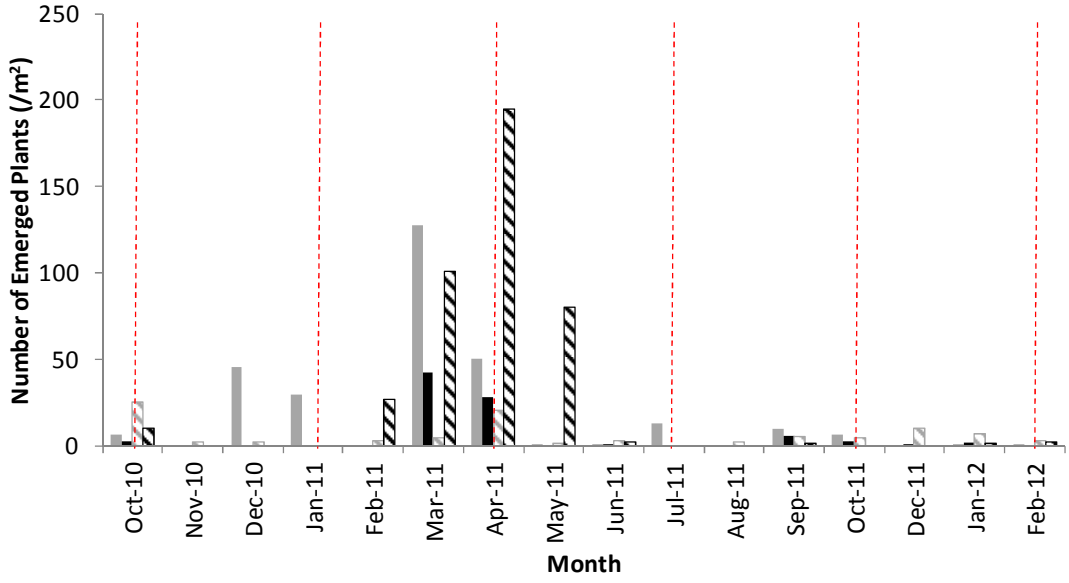

Figure 2.10: The mean number of plants emerged in the 'no-competition' plot (solid fill) and the 'zero' plot (striped fill) (per m²) for each sampling time in each site (Jack's = grey; Allan's = black) (n=4). The dashed lines represent the time of herbicide application.

2.3.5. Fireweed seed longevity

The seed longevity trial is ongoing to obtain long-term data on fireweed seed. However, over the first 12 months of burial important trends have become apparent (Figure 2.11). Like many other species, seed of fireweed appears to survive in a viable condition for longer when buried, and more so at greater depths, at least down to 10 cm, where after 12 months of burial about 30% of seeds remained viable across both sites.

On the soil surface, however, where it is expected that most fireweed seed would be present after being shed from the parent plant in most uncultivated field situations, most germinated within the first 3 months. Consequently, after 12 months only a few per cent of seed remained ungerminated and viable. These data suggest that in these relatively high rainfall environments the soil seed bank of fireweed may decline quite quickly. Where fireweed seed can be prevented from reinfesting a paddock over a 12 to 18 month period, infestations of above ground populations are also likely to decline significantly.

These seed burial trials should be augmented with seed bank population data from naturally occurring field infestations to be sure that the results from this experiment are not an artefact of the artificial burial procedures.

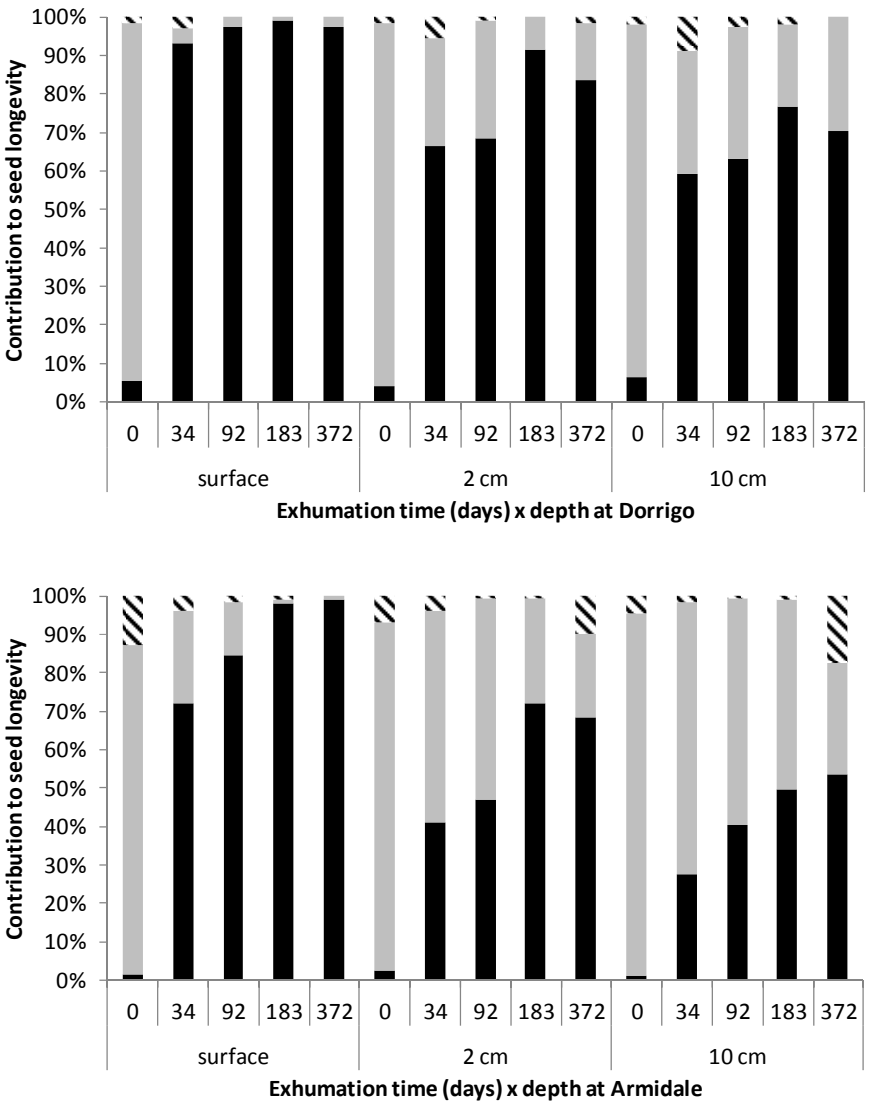

Figure 2.11: The percentage contribution to seed longevity for germinated seeds (seeds not found upon exhumation + empty seed casing) [black], viable seeds (seeds that germinated upon exhumation during incubation + remaining viable seeds) [grey] and non-viable seeds (striped) at three burial depths over time for a) Dorrigo and b) Armidale sites.

2.4. Conclusions and recommendations

Where fireweed cover was high in grazed areas, pasture biomass was considerably higher than in areas where fireweed was scattered, suggesting that the pasture was not being grazed by livestock in heavy infestations, and was therefore unavailable to them. Variability in the data though meant that this was not a statistically significant result, and requires follow-up research. Once grazing was removed, it appeared that while fireweed cover always had a significant influence on pasture biomass, the influence in this one season in a kikuyu based pasture was negligible, with less than 1% of the change in pasture biomass being accounted for by fireweed cover. But again, due to the short term nature of the trial, and the lack of fireweed growth during a large part of the experiment, it was difficult to measure true treatment differences.

Recommendation

Further research is required across a range of pasture types, climatic environments, soil types and seasons to assess the competitive impact of fireweed on pasture production. Equally important is the need to identify threshold values of fireweed densities above which fireweed reduces the availability of pasture to grazing animals due to their dislike of grazing amongst these unpalatable plants.

The study of seasonal emergence patterns for fireweed showed that the peak germination period in 2011 from March to May on the Dorrigo plateau was consistent with previous data from the County of Cumberland. Knowing this should help landholders with the timely application of control practices.

Baring of soil by removal of pasture competition through regular application of herbicide lead to greater emergence of fireweed than in pasture covered experimental plots. This result reiterates the need for strong pasture competition as a key ingredient of long-term fireweed control.

Recommendation

Research is needed on the effectiveness of herbicides on seed mortality, including herbicide timing (direct to the soil and to the plants at various stages of growth), and the effectiveness of wick wiping for fireweed control.

The seed longevity trial is continuing so that we can obtain long-term data on fireweed seed survival. However, over the first 12 months of burial important trends have become apparent. Like many other species, seed of fireweed appears to survive in a viable condition for longer when buried, and more so at greater depths, at least down to 10 cm, where after 12 months of burial about 30% of seeds remained viable across both sites.

On the soil surface, however, where it is expected that most fireweed seed would be present after being shed from the parent plant in most uncultivated field situations, most seed germinated within the first 3 months. Consequently, after 12 months only a few per cent of seed remained ungerminated and viable. These data suggest that in these relatively high rainfall environments the soil seed bank of fireweed may decline quite rapidly. Where fireweed seed can be prevented from reinfesting a paddock over a 12 to 18 month period, infestations of above ground populations are also likely to decline significantly.

Recommendation

The data from the seed burial trials conducted for this research should be augmented with seed bank population data from naturally occurring field infestations to be sure that the results of this research are not an artefact of artificial burial procedures.

3. Survey of landholders

3.1. Methods

The questionnaire form was based on an earlier fireweed survey conducted in 1985 (Sindel 1989), with nearly all questions from this original survey included unchanged in the new questionnaire.

New questions were included in the draft questionnaire based on the goals of the project, and the criteria used to determine Weeds of National Significance (WoNS), in particular to explore some of the social, environmental and economic impacts of fireweed in greater detail.

The draft questionnaire was evaluated by project steering committee members, several fireweed-impacted landholders, and NSW and Qld government staff in order to identify ambiguous questions, and ensure the questionnaire addressed the most topical issues (Attachment 1).

3.1.1. Mail survey

The goal of the survey, as per the research objectives, was to identify the impact of fireweed, a significant weed of pastures, on agricultural productivity in the fireweed affected area of Australia. We were therefore most interested in the experiences of those who had fireweed on their property, while also attempting to understand the proportion of respondents who had at least some fireweed in the impacted area.

In constructing the survey sample, current fireweed distribution data were used to estimate post codes representing the known extent of fireweed spread, using data from the Australian Virtual Herbarium and the Qld Department of Employment, Economic Development and Innovation (DEEDI; Figure 3.1).

Several organisations agreed to mail the survey to their membership or associate lists on behalf of project staff. These included South-East Qld (SEQ) Catchments, the Queensland Dairyfarmers' Organisation (QDO), and the NSW Farmers' Association (NSWFA). The post code list was provided to these organisations to filter their full mailing lists, targeting members who were graziers or dairy farmers.

Graziers and dairy farmers were also identified in the Yellow Pages by post code search, and included in the sample.

The final sample size was 1,764. A further 100 copies of the survey were sent on request to Greater Taree City Council for display at local weeds and Landcare offices.

The mail survey was distributed in late November, 2011, and responses accepted until March, 2012.

3.1.2. Internet survey

A concurrent questionnaire was published online with identical questions, using the Survey Monkey service. The internet questionnaire was developed to supplement the mail survey in the event of a lower than expected response, and to give those residing outside the known fireweed distribution area an opportunity to contribute to the research if fireweed was present on their land.

3.1.3. Maximising response

- The mail questionnaire, two yellow pages printed double side and stapled together was accompanied by a single page letter, printed in full colour and personally signed, to explain the goals of the survey and the project, and a reply-paid envelope.
- Photographs of fireweed in flower were used as banners on both the covering letter and the opening page of the internet questionnaire. These were used to draw the attention of landholders to the survey, and assist with fireweed identification for those who may have been unsure if the weed was present on their property.
- Where the questionnaire was sent by a member-based organisation, the organisation agreed in all cases to endorse the research in the covering letter. In some instances the questionnaire was mailed using organisation stationery rather than UNE stationery to further enhance its legitimacy.
- The internet and mail questionnaires were promoted through a number of electronic and paper newsletters and publications released by state government and regional NRM organisations in NSW and Qld. Potential respondents were given the opportunity to complete the questionnaire online, or to contact project staff by telephone or email and request a paper copy of the form.
- A press release was written and published by the University of New England, with a particular focus on rural newspapers and local newspapers in coastal and hinterland NSW and South-East Qld, for printing just prior to the mailout of surveys.
- The survey was conducted at a time when fireweed was flowering near its peak, and therefore in the forefront of land manager thinking. As with the first survey, it was considered important that the weed be easily recognised by farmers.

3.1.4. Non-response bias

The possibility of non-response bias is one of the most important possible limitations of a survey of this type.

It may be argued, for example, that significant differences between respondents and non-respondents are attributable to those having fireweed on their property being more likely to respond to the survey, compared with those who did not have fireweed. The questionnaire (Attachment 1) asked respondents to identify whether fireweed occurred on their property. If not, respondents were asked to indicate the main farming enterprise of their property, and then return the form.

If fireweed was on the property, respondents were asked to complete all questions.

Some assumptions may be made about respondents and non-respondents based on whether or not fireweed occurred on their property:

- Amongst those who had fireweed on their property, it may be assumed that some were unwilling to respond, either because they were too busy to complete and return the questionnaire, or because they did not want to admit fireweed was present on the property. Likewise, some may have been willing to respond simply because they were interested in fireweed control, and wanted to be involved in the research and find out more.
- Amongst those who did not have fireweed on their property, some potential respondents may not have completed the form simply because they considered the survey did not apply to them. On the other hand, some may have been willing to return the survey, either because they were proud that they did not have fireweed, or because they were keen to avoid possible follow-up or reminders (which were not used in this survey).

It can be seen, then, that there are factors that could lead to either over- or under-estimates of the proportion of properties affected by fireweed. In the absence of any reasons to suggest that either type of factor prevailed over the other, it can only be concluded the estimate of the proportion of properties affected by fireweed is unlikely to be severely biased in either direction due to non-response.

3.1.5. Analysis

Responses were categorised into regions (groups of post codes) where a post code was provided (Figure 3.1). Several regions were based on those created for regional analysis of the original fireweed survey in 1985 (Figure 3.2). In order to group 2011 respondents into corresponding regions, the original mailing lists from the 1985 survey were obtained, and lists of post codes produced from these corresponding to each region. Using these post codes, a lookup table was created in Microsoft Excel to identify in which region respondents from the 2011 survey needed to be included. The 1985 survey region map (Figure 3.2) was then overlaid onto the 2011 response map by post code (Figure 3.1) to confirm the regions had been created accurately.

Given the continued spread of fireweed since the 1980s, a number of new regions were created. These included South-East Qld, Mid-North Coast, Northern Tablelands/NW Slopes, and Southern Inland NSW (Figure 3.1).

The purpose of including these regions was to allow comparative analysis with the 1985 survey, to demonstrate significant changes in the spread, impact and management of fireweed at a regional level over time.

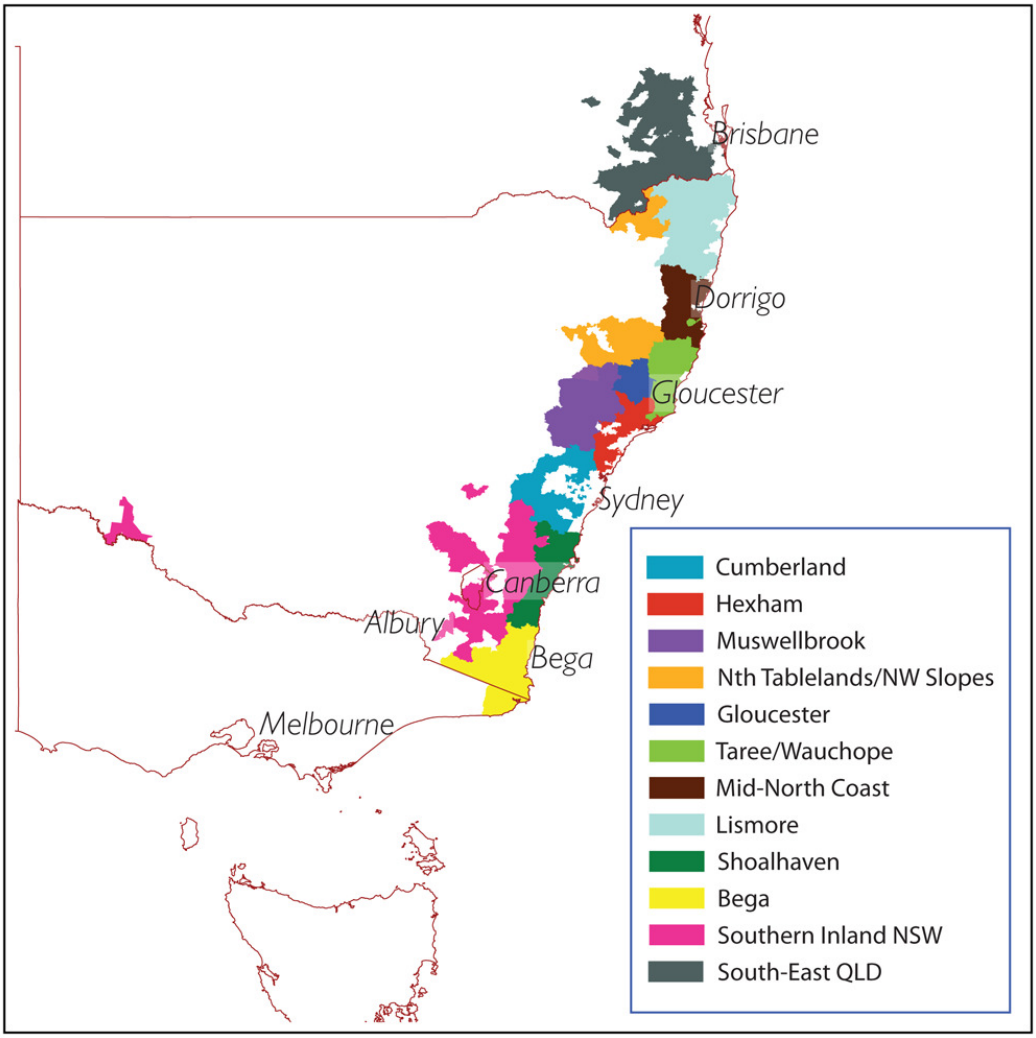

Figure 3.1: Regions sampled in the survey 2011

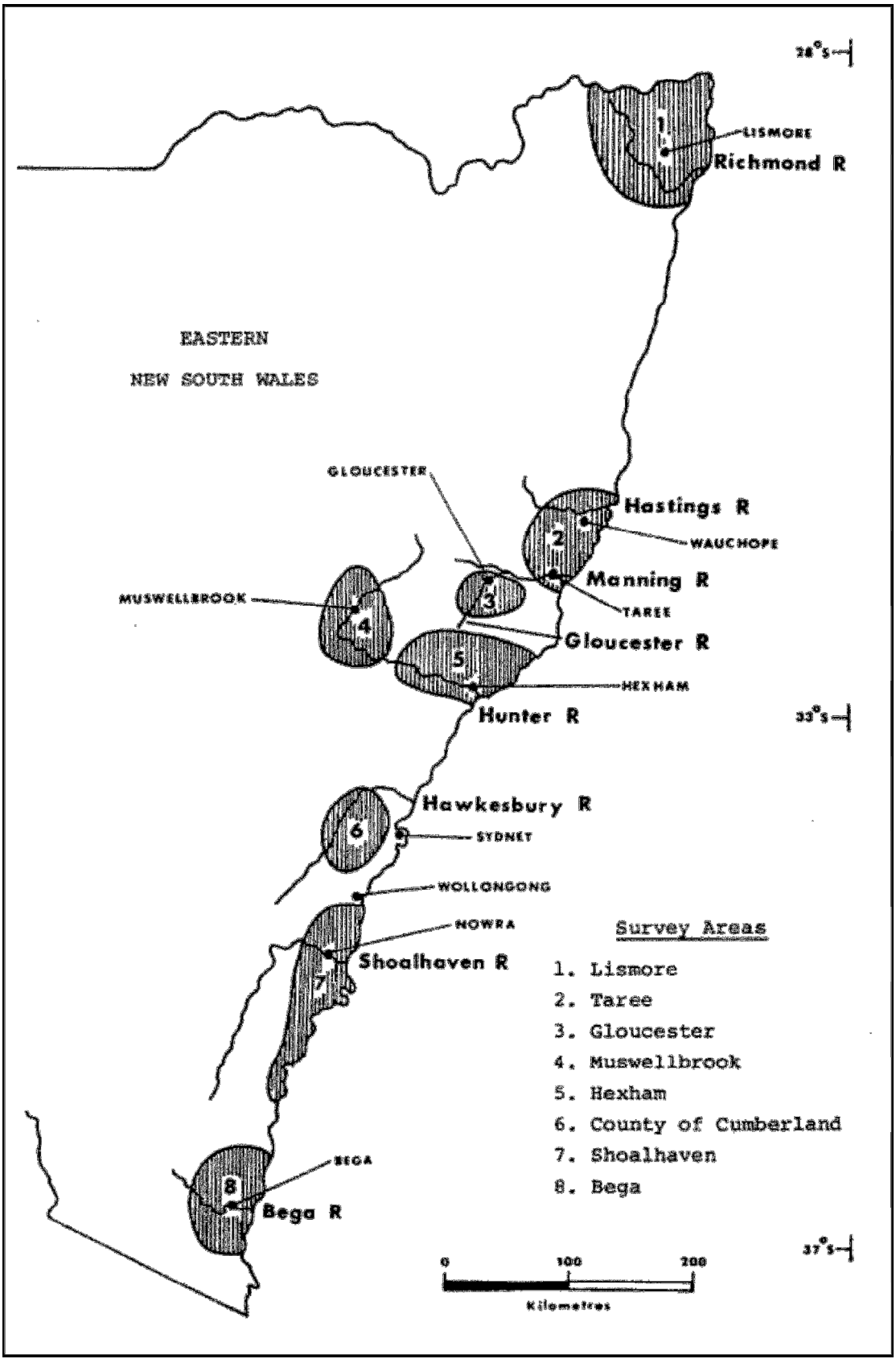

Figure 3.2: Regions sampled in the survey 1985 (from Sindel 1989)

Comparative analysis between the 1985 and 2011 surveys was conducted where questions were identical, and responses to both surveys have been included in the tables where appropriate. Where 2011 data have been analysed alone, the chi-square test was used to identify the significance of cross-tabulations, with a p value of <0.05 taken to indicate a statistically significant relationship in the data. Statistically significant changes over time (comparing the two surveys) were identified using the binomial test and Mann-Whitney U test in the statistical software package SPSS.

The binomial test is used to identify significant changes in proportions of responses to questions with nominal response categories (for example, the proportion of respondents who agree that fireweed looks bad because it poisons livestock). The test was used on relevant variables in the 2011 data set by comparing the overall response with that to the 1985 survey. A p value of <0.05 indicated that the proportion of respondents in favour of a response in 2011 had changed significantly from the overall response in 1985.

The Mann-Whitney U test was used to test whether the mean of an ordinal variable (for example, how long fireweed had been present on the respondent's property in terms of a small number of year ranges) was significantly different in 2011 from 1985. The test was used to show whether there had been a significant increase or decrease in the ratings given on ordinal variables between the first and second surveys.

Since the original (1985) survey data were no longer available, but the proportions responding to each ordinal response item were available, a synthetic data set was created for the questions for which the Mann-Whitney U test was used. The proportion of responses for each response item was based on percentages included in Sindel (1989), and the number of responses in the synthetic 1985 data set matched to the number of responses to the actual survey. While it is not known whether all respondents had answered each of the questions in the 1985 survey, small departures from the total number of responses were expected to make only a trivial difference to the Mann-Whitney U test statistic.

As with the binomial test, a Mann-Whitney U test p value of <0.05 was taken to represent a significant change in response.

3.1.6. Limitations to comparative analysis

Changed circumstances over time in the study area meant that survey sample construction differed significantly for the 1985 and 2011 surveys. Postal survey sample construction for 2011 has been described in Section 3.1.1.

In 1985, a sample of 780 farmers was constructed and stratified over the eight regions (Figure 3.2). These eight regions corresponded at the time to areas served by particular dairy co-operatives, and were all regions in which fireweed was expected to occur.

Sixty dairy farmers were randomly selected from each of the areas using lists supplied by the various dairy co-operatives. In addition to these 480 dairy farmers, 60 graziers (almost exclusively running beef cattle) were randomly selected from each of the five northern areas identified, using telephone directories and lists provided by district agronomists.

The 2011 postal survey sample construction differed for a number of reasons:

- The former dairy co-operatives had merged or been bought out by larger dairy or food production corporations.
- Preliminary investigation suggested these corporations were unlikely to be willing to participate in survey distribution, given impracticalities and concerns over maintaining client privacy.
- Preliminary investigation also suggested that district agronomists no longer kept comprehensive lists of beef producers in their region, and even if so, that they would not be at liberty to divulge these details.
- It was considered necessary to include all beef and dairy farmers for whom address details were available in the 2011 survey sample:
    - Aggregation of some farms and fragmentation of others into smaller lifestyle blocks, coupled with reduced farm profitability, meant that the number of dairy and beef farms in the study area appeared to have declined over time.
    - Survey fatigue was likely to mean a lower response rate than that obtained from the 1985 survey (74%).

Although the survey sample and mailout methods differed from 1985 to 2011, these differences are unlikely to result in systematic differences in the types of farms to which surveys were sent. Given the matching of post codes for the two surveys, we are confident that the regional comparisons are unlikely to be significantly affected by artefacts of the sampling methods.

3.1.7. Table conventions

All tables presenting data by region carry a column or a row for the overall survey total. This total includes respondents who did not provide a post code that would have enabled them to be included in the regional analysis. Other cross-tabulations include a row at the base of the table showing the number of respondents included in the table. The statistics for a chi-square, binomial or Mann-Whitney U test are included immediately below the tables where relevant. Categories for which a significant binomial or Mann-Whitney U test result were found are marked within the tables.

A number of tables include only a subset of the total survey response group (for example, those who had fireweed on their property, or those who attempted to control fireweed). In these cases, the subset is indicated in the table caption. Where 2011 and 1985 data are presented together, 1985 data have been included in brackets and italicised.

3.2. Results and discussion

A 30 per cent response rate was obtained from the mail survey (528 responses), with a further 403 responses made to the online survey, comprising a total of 931 responses. The effective response rate to the mail survey may have been slightly higher, as some respondents who received the survey in the mail may have chosen to complete it online instead.

Responses by region are listed in Table 3.1. There were 121 responses provided without a post code, however 82 of these also stated they had no fireweed on their property, and so were not required to complete the remaining survey questions (including the one asking for post code to be provided). Therefore, data presented for comparative analysis by region in the remainder of this report does not add up to the total for all respondents, as those who did not provide a post code have necessarily been excluded from regional analysis. Where appropriate, those who did not have fireweed on their property were also excluded from analysis.

Table 3.1: Number of responses for each survey region

Number of responses by region	
Cumberland	37
Hexham	46
Muswellbrook	37
Northern Tablelands/NW Slopes	38
Gloucester	20
Taree/Wauchope	70
Mid-North Coast	80
Lismore	83
Shoalhaven	106
Bega	132
Southern Inland NSW	21
South-East QLD	138
No post code given	*121*

3.2.1. Enterprises

Of the 931 respondents, 53.6 per cent cited their main farm enterprise as beef cattle, 15.3 per cent as dairying, 6.9 per cent as sheep, and 1.8 per cent as goats. A further 16.8 per cent indicated some other form of main farm enterprise. Common responses for these other categories included conservation, wildlife refuges and forestry, hobby and lifestyle farming, recreational use, horses, various horticultural enterprises, and subsistence production.

Respondents to the mail survey were significantly more likely to be involved in dairy production (25.9 per cent of respondents) compared with those who completed the survey online (3.4 per cent), reflecting the targeted nature of the mail survey, which was specifically posted to dairy farmers in NSW and Qld via the NSW Farmers' Association and QDO member mailing lists.

Likewise, respondents to the online survey were significantly more likely to be involved in forms of farm enterprise (37.6 per cent) other than those listed above, compared with mail survey recipients (2.6 per cent). While the cause of this discrepancy is not known, it may reflect the relative ease of internet access available to hobby, conservation and small scale subsistence landholders, and the fact that they are much less likely to be members of commercial farmer representative groups such as NSWFA and QDO.

3.2.2. Property size

Mean property size was 366.4 hectares, and was significantly different between mail (605.6 hectares) and online (126.1 hectares) response groups. Two respondents were excluded from property size means, one a national park manager responsible for 100,000 hectares, and the other a local control area representative responsible for over 300,000 hectares.

3.2.3. Fireweed occurrence

Fireweed was present on 783 (85 per cent) of respondents' properties, comprising 74 per cent of respondents to the mail survey and 98 per cent of respondents to the online survey (Table 3.2). Overall, 103 respondents (11.2 per cent of total replies) considered fireweed to be under control, a figure similar to the 9 per cent of respondents in the 1985 survey.

All respondents in the Hexham, Gloucester, Taree/Wauchope, Mid-North Coast and Shoalhaven regions had at least some fireweed on their property. There were more properties with 'large amounts' of fireweed in the Bega, Lismore and Shoalhaven regions than other regions, although Bega respondents were also the most likely to have considered fireweed under control on their property. This may be due to high levels of awareness and interest in fireweed control in this region over the last few years.

Fireweed appears to be less of a problem for Cumberland, Northern Tablelands/NW Slopes and Southern Inland NSW respondents, with a relatively high proportion recording no fireweed on their property, or a small amount at worst. The impact of fireweed appears to have declined in Cumberland since the 1985 survey, while as yet fireweed appears to be a relatively recent arrival in the Northern and Southern Tablelands, where its impact is not yet as severe as elsewhere.

Comparison with data from the 1985 survey suggests that over time fireweed infestation has become more severe in the Bega, Shoalhaven and Lismore regions where approximately one fifth of respondents have indicated they have a large amount on their property in all three regions, compared with 10 per cent

or less in 1985. Likewise Muswellbrook and Bega in 1985 had nearly a third and two thirds of landholders with no fireweed respectively, but those percentages are now 2.7 and 3.0 per cent.

Although the Mid-North Coast and South-East Qld regions were not surveyed in 1985, fireweed appears to be relatively widespread in these regions, with larger infestations more common in the Mid-North Coast.

Table 3.2: Occurrence of fireweed, as a percentage of total response 2011 (1985)

	Survey regions												
	Overall survey*	**Cumberland**	**Hexham**	**Muswellbrook**	**Northern Tablelands/ NW Slopes**	**Gloucester**	**Taree/ Wauchope**	**Mid-North Coast**	**Lismore**	**Shoalhaven**	**Bega**	**Southern Inland NSW**	**South-East Qld**
Absent	15.1 *(10)*	21.6 *(4)*	0 *(0)*	2.7 *(29)*	32.4 *(n/a)*	0 *(0)*	0 *(0)*	0 *(n/a)*	1.2 *(0)*	0 *(14)*	3 *(65)*	61.9 *(n/a)*	10.1 *(n/a)*
Small amounts	29.2 *(30)*	37.8 *(35)*	17.8 *(21)*	27 *(56)*	48.6 *(n/a)*	25 *(24)*	24.3 *(18)*	35 *(n/a)*	19.8 *(29)*	36.8 *(43)*	27.3 *(25)*	23.8 *(n/a)*	44.9 *(n/a)*
Moderate amounts	32 *(40)*	21.6 *(42)*	55.6 *(50)*	54.1 *(9)*	8.1 *(n/a)*	65 *(59)*	47.1 *(48)*	41.2 *(n/a)*	53.1 *(46)*	27.4 *(20)*	28 *(2)*	9.5 *(n/a)*	27.5 *(n/a)*
Large amounts	12.6 *(11)*	2.7 *(13)*	13.3 *(19)*	10.8 *(0)*	8.1 *(n/a)*	5 *(15)*	15.7 *(17)*	12.5 *(n/a)*	21 *(10)*	17.9 *(4)*	21.2 *(0)*	0 *(n/a)*	6.5 *(n/a)*
Under control	11.2 *(9)*	16.2 *(6)*	13.3 *(10)*	5.4 *(6)*	2.7 *(n/a)*	5 *(2)*	12.9 *(17)*	11.2 *(n/a)*	4.9 *(15)*	17.9 *(19)*	20.5 *(8)*	4.8 *(n/a)*	10.9 *(n/a)*
*n (2011 only)***	*922***	*37*	*45*	*37*	*37*	*20*	*70*	*80*	*81*	*106*	*132*	*21*	*138*

chisq = 288.6, d.f. = 44, p = 0 (2011 only)

** Overall survey response includes those who did not provide a post code.*

*** Several respondents did not answer this question, hence n is less than the total number of responses received. It is not known whether these respondents had fireweed on their property.*

3.2.4. Spread

Of those who have fireweed on their property, 21 per cent observed its arrival within the last five years, while for a further 26 per cent the weed has been on their property for between 5 and 10 years. Over 25 per cent of respondents have had fireweed on their property for more than 20 years (Table 3.3). There were significant differences in duration of spread amongst respondents overall between the 1985 and 2011 surveys (Mann Whitney U Test p = 0). Respondents in 2011 were significantly more likely to have had fireweed on their property for more than 20 years, as one would expect.

For all regions surveyed in both 1985 and 2011, the duration of fireweed presence has increased, suggesting that fireweed has become an entrenched part of the landscape. This is particularly observable in the Shoalhaven and Bega regions, where fireweed had not been considered present for more than 10 years at the time the 1985 survey was conducted. The response suggests that fireweed has been present for longest in Hexham, Gloucester and Muswellbrook, which is where historical reports indicate that fireweed was first found. Fireweed appears to be a relatively recent phenomenon in Southern Inland NSW, the Northern Tablelands/NW Slopes, and South-East Qld.

The areas where there is a relatively high percentage of respondents indicating that fireweed has been present for less than 5 years include Cumberland, Northern Tablelands/NW Slopes, Shoalhaven, Bega, Southern Inland NSW and South-East Qld. This indicates these may be areas of high rates of fireweed spread.

Mean scores reflecting duration of fireweed presence were produced for each post code for which scores were given, and are presented in Figure 3.3. The map shows that fireweed has been present for longer in parts of the NSW far north coast, around Port Macquarie, the Gloucester/Taree region, the lower Hunter Valley, and the south-west fringe of Sydney. More recent spread has occurred in South-East Qld, South-East NSW and the NSW Southern Tablelands.

Table 3.3: Duration of fireweed presence, as a percentage of respondents with fireweed 2011 (1985)

		Survey regions											
	Overall survey*	**Cumberland**	**Hexham**	**Muswellbrook**	**Northern Tablelands/ NW Slopes**	**Gloucester**	**Taree/ Wauchope**	**Mid-North Coast**	**Lismore**	**Shoalhaven**	**Bega**	**Southern Inland NSW**	**South-East Qld**
Less than 5 years	20.8 *(29)*	20.7 *(62)*	2.3 *(4)*	2.8 *(63)*	32 *(n/a)*	0 *(0)*	7.4 *(14)*	10.3 *(n/a)*	1.2 *(29)*	19.4 *(89)*	33.3 *(94)*	66.7 *(n/a)*	46.7 *(n/a)*
5 to 10 years	26.1 *(29)*	17.2 *(36)*	4.5 *(13)*	16.7 *(8)*	28 *(n/a)*	20 *(27)*	25 *(50)*	32.1 *(n/a)*	12.2 *(29)*	26.2 *(11)*	38.1 *(6)*	22.2 *(n/a)*	32.5 *(n/a)*
10 to 20 years	28 *(28)*	37.9 *(2)*	27.3 *(28)*	27.8 *(25)*	20 *(n/a)*	20 *(49)*	29.4 *(36)*	34.6 *(n/a)*	37.8 *(25)*	35.9 *(0)*	19.8 *(0)*	11.1 *(n/a)*	16.7 *(n/a)*
20 to 30 years	14.6 *(10)*	20.7 *(0)*	22.7 *(38)*	25 *(0)*	20 *(n/a)*	20 *(22)*	19.1 *(0)*	20.5 *(n/a)*	23.2 *(7)*	15.5 *(0)*	7.9 *(0)*	0 *(n/a)*	2.5 *(n/a)*
More than 30 years	10.5 *(4)*	3.4 *(0)*	43.2 *(17)*	27.8 *(4)*	0 *(n/a)*	40 *(2)*	19.1 *(0)*	2.6 *(n/a)*	25.6 *(10)*	2.9 *(0)*	0.8 *(0)*	0 *(n/a)*	1.7 *(n/a)*
n (2011 only)	*769*	*29*	*44*	*36*	*25*	*20*	*68*	*78*	*82*	*103*	*126*	*9*	*120*

chisq = 301.1, d.f. = 44, p = 0 (2011 only)

** Mann-Whitney U Test p = 0. Overall survey response includes those who did not provide a post code*

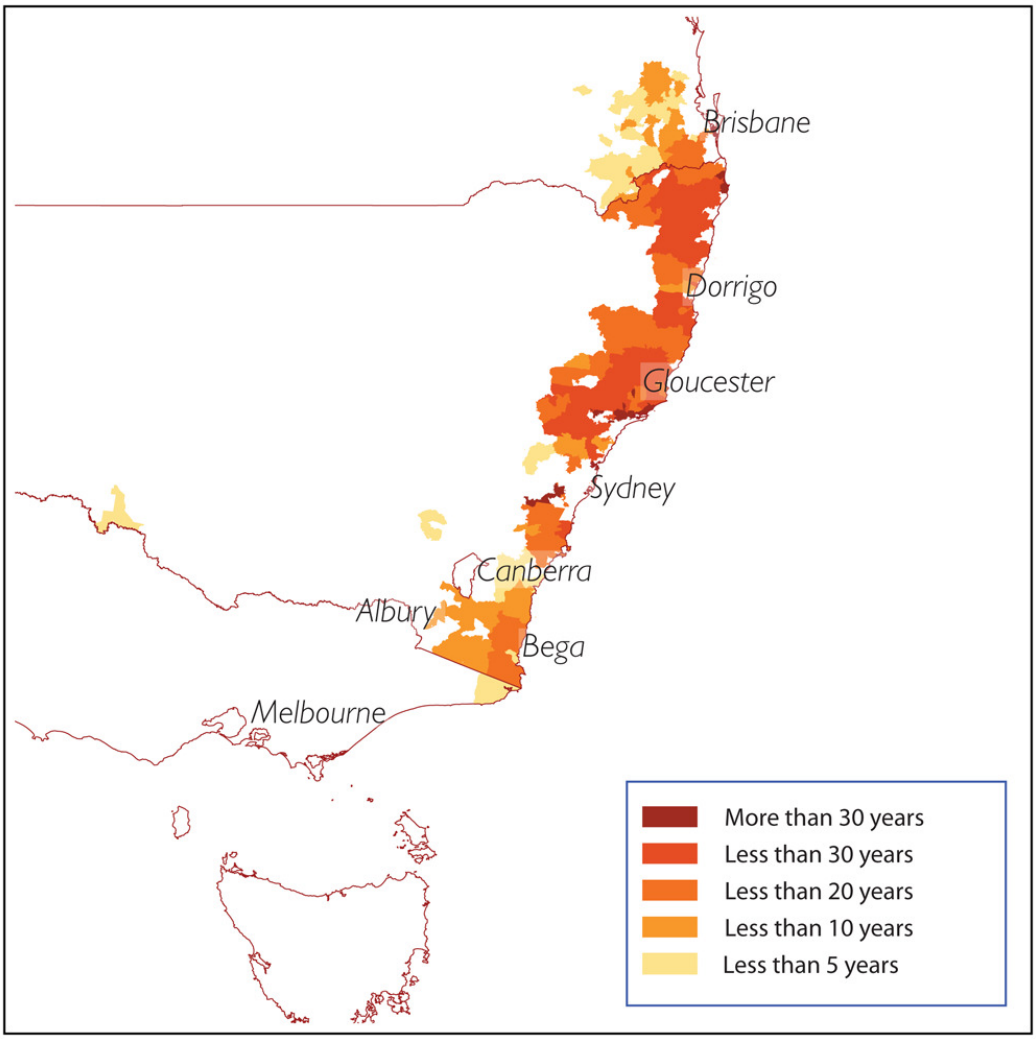

Figure 3.3: Duration of fireweed presence – mean by post code

Respondents were able to nominate as many fireweed spread vectors that they considered might have played a part in spreading the weed onto their property (Table 3.4). A large majority of respondents from all regions considered that fireweed spread onto their property as a result of wind blown seed, while birds or other animals, and contaminated vehicles or machinery, were also considered important fireweed spread pathways.

Wind blown seed was considered a particularly important method of spread by respondents in the Cumberland, Bega and Shoalhaven regions, and relatively less important in the Muswellbrook region. Contaminated vehicles and machinery was rated relatively highly by Southern Inland NSW respondents.

Contaminated seed, grain and hay, and livestock movement, were not considered important fireweed spread vectors overall, except livestock were considered an important vector in Muswellbrook and the Northern Tablelands/NW Slopes.

Over 8 per cent of respondents overall believed that other methods were responsible for spreading fireweed onto their property. A number of respondents considered that fireweed had spread via flood waters, while several others suggested that poor control by neighbours resulted in fireweed continually spreading onto their property, presumably by wind. Other spread pathways listed included fertiliser, contractors and utility workers, and disturbed soil. However, many stated that they did not know how fireweed originally spread onto their property, while others said that the weed was already present when they moved onto the property.

Table 3.4: Pathways of fireweed spread, as a percentage of respondents with fireweed 2011

		Survey regions											
	Overall survey*	**Cumberland**	**Hexham**	**Muswellbrook**	**Northern Tablelands/ NW Slopes**	**Gloucester**	**Taree/ Wauchope**	**Mid-North Coast**	**Lismore**	**Shoalhaven**	**Bega**	**Southern Inland NSW**	**South-East Qld**
Contaminated hay	9.0	14.3	15.9	14.7	0.0	10.0	10.6	6.5	10.1	12.5	7.8	0.0	8.3
Livestock moved onto property	11.0	10.7	9.1	35.3	26.1	15.0	15.2	13.0	12.7	8.7	2.3	12.5	9.9
Wind blown seeds	80.6	96.4	84.1	64.7	78.3	85.0	84.8	87.0	74.7	90.4	90.6	75.0	75.2
Contaminated vehicles or machinery	15.4	7.1	11.4	17.6	4.3	20.0	22.7	14.3	15.2	19.2	17.2	25.0	12.4
Contaminated seed or grain	3.8	3.6	2.3	0.0	0.0	5.0	12.1	3.9	7.6	1.9	1.6	0.0	4.1
Birds or other animals	22.6	21.4	25.0	29.4	26.1	25.0	16.7	22.1	27.8	26.9	15.6	25.0	25.6
Other	8.4	3.6	15.9	17.6	0.0	5.0	10.6	14.3	15.2	2.9	2.3	12.5	7.4
n	*788*	*28*	*44*	*34*	*23*	*20*	*66*	*77*	*79*	*104*	*128*	*8*	*121*

** Overall survey response includes those who did not provide a post code*

3.2.5. Size of the problem

Respondents were asked to indicate the extent to which they believed fireweed was a problem on their land (Table 3.5).

Overall, the data suggest that fireweed is a minor to moderate problem for most landholders. However, as was the case in the 1985 survey, the extent of the problem varied significantly between regions, with a relatively high proportion of respondents considering fireweed a major problem in both the Bega and Shoalhaven regions.

In regions where fireweed infestation appears to be a relatively recent phenomenon on many farms, such as South-East Qld, the Northern Tablelands/NW Slopes, and Southern Inland NSW, fireweed is considered a major problem only by a relatively small proportion of respondents. Similarly, the weed is considered a major problem by a low proportion of respondents in the Muswellbrook, Gloucester and Taree/Wauchope regions, where fireweed has been present for a considerable period of time. Possible explanations for this include:

- Farmers in these regions have developed, through longer experience, ways of managing fireweed with some effectiveness.
- Some regions may be more prone to major fireweed infestations than others, due to a range of factors including regional climate and land use patterns.
- Farmers in these regions may have become accustomed to the weed.

It is notable, however, that the proportion of respondents who consider fireweed to be 'no problem' decreased markedly since 1985 in the Hexham, Muswellbrook, Shoalhaven and Bega regions, while it increased somewhat in Cumberland. Only 7.5 per cent of Mid-North Coast respondents consider fireweed to be no problem. Fireweed has at least some impact on farm management for the large majority of farmers in all regions.

Overall, the proportion of respondents who consider fireweed to be no problem on their property decreased significantly in comparison with the 1985 survey, while the proportion who considered it a major problem increased significantly (Mann-Whitney U Test $p = 0.019$), while the proportion considering it a minor or moderate problem changed only a little.

Responses to the extent of the fireweed problem were coded, and mean scores produced for each post code where a response was received. A mean score between two categories was recoded to match the closest categorical whole number score. For example, where '1' refers to 'no problem', and '2' refers to 'a minor problem', a mean score of 1.49 was coded as no problem, and a mean score of 1.50 as a minor problem. The results are presented in Figure 3.4.

The map shows that fireweed tends to be considered a moderate to major problem in many coastal or hinterland areas, and is considered less of a problem

overall on many parts of the ranges and further inland. Fireweed is considered a moderate to major problem around Ipswich, Lismore, Coffs Harbour and Port Macquarie, Hexham and Bulahdelah, parts of the south-west Sydney basin, Nowra, Bateman's Bay and Bega.

As in 1985, a significant correlation was found between the existence of fireweed on property and how farmers perceived the fireweed problem (Table 3.6). The size of the fireweed problem is often related to level of infestation. Generally, for a small occurrence of fireweed, respondents considered the weed to pose little or no problem. Those who had a moderate fireweed infestation generally considered it a minor or moderate problem, while those with a large infestation generally considered it a moderate or major problem. For those who believed they had fireweed controlled on their property, the majority considered it either a minor or moderate problem.

Similarly, a significant correlation was found between the duration of fireweed presence on the property and how the fireweed problem was perceived (Table 3.7). Those who have had the weed on property for less time are significantly more likely to consider fireweed either no problem or a minor problem, while those who have had a longer term fireweed infestation were more likely to consider it a moderate or major problem. It is notable, however, that those who have had fireweed for more than 30 years were relatively ambivalent about the size of the fireweed problem, with a similar proportion considering it a minor, moderate and major problem alike.

Once introduced onto a property, the fireweed problem seems to continue to increase and peak in intensity after 20-30 years, but after this time some people either seem to learn to live with fireweed, or learn to manage it.

Sheep producers were significantly less likely to consider fireweed to be a moderate or major problem than beef cattle producers and dairy farmers (Table 3.8). This is expected, as sheep are more tolerant of the pyrrolizidine alkaloids present in fireweed than cattle, so that fireweed causes less problems for sheep producers.

Table 3.5: Size of the fireweed problem as perceived by farmers, as a percentage of respondents with fireweed 2011 (1985)

		Survey regions											
	Overall survey*	**Cumberland**	**Hexham**	**Muswellbrook**	**Northern Tablelands/ NW Slopes**	**Gloucester**	**Taree/ Wauchope**	**Mid-North Coast**	**Lismore**	**Shoalhaven**	**Bega**	**Southern Inland NSW**	**South-East Qld**
No problem	13.3 *(19)*	20.7 *(10)*	6.7 *(19)*	8.6 *(58)*	28 *(n/a)*	5 *(2)*	12.9 *(8)*	7.5 *(n/a)*	12 *(19)*	8.5 *(26)*	7 *(52)*	27.3 *(n/a)*	25.6 *(n/a)*
Minor problem	38.7 *(36)*	44.8 *(41)*	42.2 *(27)*	54.3 *(28)*	40 *(n/a)*	60 *(46)*	35.7 *(33)*	41.2 *(n/a)*	31.3 *(48)*	37.7 *(34)*	38.3 *(29)*	45.5 *(n/a)*	36.8 *(n/a)*
Moderate problem	31.5 *(33)*	20.7 *(37)*	35.6 *(48)*	31.4 *(14)*	24 *(n/a)*	25 *(43)*	41.4 *(41)*	36.2 *(n/a)*	44.6 *(19)*	30.2 *(19)*	25 *(5)*	18.2 *(n/a)*	25.6 *(n/a)*
Major problem	16.5 *(12)*	13.8 *(12)*	15.6 *(6)*	5.7 *(0)*	8 *(n/a)*	10 *(9)*	10 *(18)*	15 *(n/a)*	12 *(14)*	23.6 *(21)*	29.7 *(14)*	9.1 *(n/a)*	12 *(n/a)*
n (2011 only)	*788*	*29*	*45*	*35*	*25*	*20*	*70*	*80*	*83*	*106*	*128*	*11*	*125*

chisq = 78.2, d.f. = 33, p = 0 (2011 only)

** Mann-Whitney U Test p = 0.019. Overall survey response includes those who did not provide a post code*

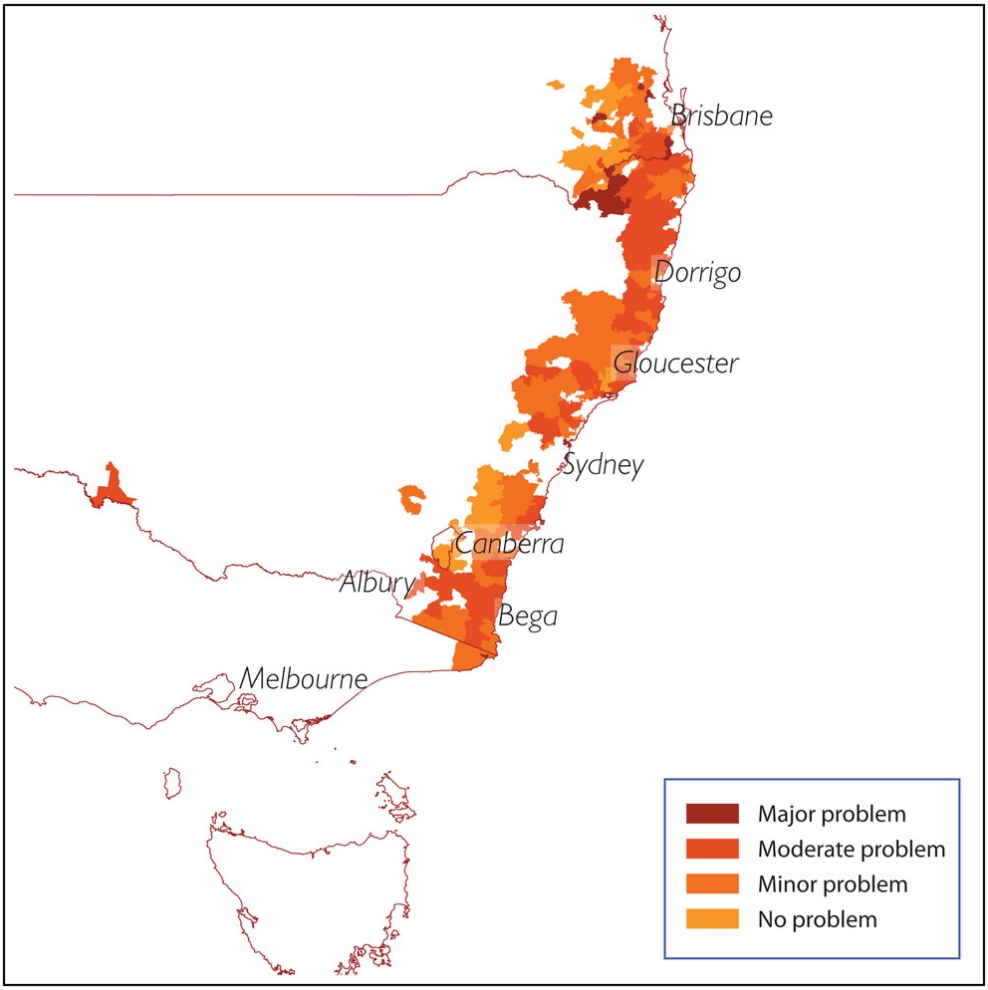

Figure 3.4: Size of the fireweed problem as perceived by farmers – mean by post code

Table 3.6: Relationship between fireweed occurrence and extent of fireweed problem, as a percentage of responses

Size of the fireweed problem as perceived by farmers	***Occurrence of fireweed***			
	Small amounts	**Moderate amounts**	**Large amounts**	**Under control**
No problem	27.5	2.7	0.9	14.7
Minor problem	62.6	31.6	2.6	42.2
Moderate problem	7.9	55.1	32.5	24.5
Major problem	1.9	10.5	64.1	18.6
n	*265*	*294*	*117*	*102*

chisq = 464.5, d.f. = 9, p = 0

Table 3.7: Relationship between duration of fireweed presence and extent of fireweed problem, as a percentage of responses

Size of the fireweed problem as perceived by farmers	Duration of fireweed presence				
	Less than 5 years	5 to 10 years	10 to 20 years	20 to 30 years	More than 30 years
No problem	45.4	6.5	3.7	4.1	9.7
Minor problem	44.2	59.1	19.2	20.5	35.9
Moderate problem	7.6	26.0	65.6	27.5	21.4
Major problem	2.7	8.4	11.5	48.0	33.0
n	*328*	*369*	*375*	*171*	*103*

chisq = 755.8, d.f. = 12, p = 0

Table 3.8: Relationship between main property enterprise and extent of fireweed problem, as a percentage of responses

Size of the fireweed problem as perceived by farmers	Duration of fireweed presence				
	Dairying	Beef cattle	Sheep	Goats	Other
No problem	12.0	8.9	26.5	35.7	20.5
Minor problem	37.0	33.7	58.8	21.4	50.3
Moderate problem	34.3	36.5	11.8	35.7	20.5
Major problem	16.7	20.9	2.9	7.1	8.6
n	*108*	*460*	*34*	*14*	*151*

chisq = 65.1, d.f. = 12, p = 0

3.2.6. Why fireweed is a problem

Respondents were asked to indicate the reason or reasons they consider fireweed to be a problem on their property (Table 3.9).

Poisoning and poor growth of stock

Importantly, approximately 7 per cent of respondents considered that fireweed had been or was currently poisoning livestock, while 7 per cent also believed the weed caused poor livestock growth, both significantly higher responses than received for the 1985 survey, using the binomial test of significance (Table 3.9). Livestock poisoning was noted by higher proportions of respondents in Southern Inland NSW, Lismore, Gloucester, Mid-North Coast and South-East Qld. Poor livestock growth was considered worst in Hexham, Taree/Wauchope and the Mid-North Coast regions.

Potential to get worse

Over 69 per cent of respondents overall believe that fireweed has the potential to rapidly get worse (Table 3.9). The majority of respondents from each region considered this a reason for fireweed being a problem. However, it is notable that respondents in regions where fireweed is a more recent occurrence (such as

Southern Inland NSW, Northern Tablelands/NW Slopes, South-East Qld, Bega and Shoalhaven) were more likely to consider this important than those from some regions where the weed has been established for longer, such as Hexham, Muswellbrook and Gloucester. This suggests that farmers are generally aware of the high invasive and impact potential of fireweed.

Appearance on the farm

Fireweed infestations on property looked bad to over 27 per cent of respondents overall, down from 45 per cent response to the 1985 survey (Table 3.9). This issue was particularly important in the Gloucester, Taree and Hexham regions, and suggests that the longer a weed is present in an area, the more likely landholders will become used to it and not be ashamed of its presence on their farm.

Difficulty controlling

Around 54 per cent of respondents overall consider fireweed to be difficult to control, an issue that appears particularly important to those from the established fireweed regions of Lismore, Bega and Shoalhaven (Table 3.9). Around 62 per cent of respondents from South-East Qld also consider fireweed difficult to control. Of the regions where fireweed has been established for longer, only in Cumberland did less than half of respondents (45.8 per cent) consider this to be an issue.

Over 25 per cent of respondents overall considered fireweed a problem because it occurred in difficult terrain (Table 3.9). Of the regions where fireweed is more widely established, difficult terrain appeared to be an issue for respondents from Mid-North Coast, South-East Qld, Bega and Shoalhaven. Difficult terrain was only an issue for 11 per cent of respondents from Gloucester. In areas where a weed such as fireweed occurs in difficult terrain, biological control becomes a particularly attractive option.

Presence in hay or silage

The proportion of respondents who noted fireweed in crops or pasture used for hay or silage decreased significantly from 24 per cent in 1985 to over 14 per cent in 2011 (Table 3.9). Over time this issue appears to have become markedly less important in the Cumberland, Taree/Wauchope, Shoalhaven, and Hexham districts, though it is unknown whether this is a reflection of management changes, or reduction in the amount of hay and silage produced in these regions.

Reduction in productivity

Just over 50 per cent of respondents overall indicated that fireweed competed with crops or pasture, while a further 22.3 per cent suggested that fireweed is a problem because it reduces the area stock are able to graze (Table 3.9). There has been a statistically significant reduction in both these figures overall, compared with the 1985 survey. However, it is notable that fireweed's ability to compete with crops and pasture, and to restrict stock grazing area, are

considered important by a higher proportion of respondents in several fireweed regions, including Muswellbrook, Bega, Shoalhaven, and Gloucester.

The abundance of fireweed varies greatly from season to season, and so respondents were asked to estimate the reduction in pasture or crop productivity for 'normal' and 'bad' fireweed years (Table 3.10). Although only 21.5 per cent of respondents felt that fireweed reduced pasture or crop productivity by more than 10 per cent in a 'normal' year, 37 per cent believed that such reductions occurred in a 'bad' year. The Mann-Whitney U Test ($p = 0.018$) suggested there was a significant change in response to this question based on 'bad' fireweed years in the 2011 survey compared with the 1985 survey. A greater proportion of respondents felt that fireweed had no impact on productivity in a 'bad' year, however a slightly higher proportion similarly felt the weed reduced productivity by 20 per cent or more, perhaps indicating a slight polarisation of views on fireweed impact.

Table 3.9: Reasons why farmers consider fireweed a problem, as a percentage of respondents with fireweed 2011 (1985)

		Survey regions											
	Overall survey*	Cumberland	Hexham	Muswellbrook	Northern Tablelands/ NW Slopes	Gloucester	Taree/ Wauchope	Mid-North Coast	Lismore	Shoalhaven	Bega	Southern Inland NSW	South-East Qld
Looks bad**	27.2 *(45)*	29.2 *(52)*	39 *(52)*	33.3 *(19)*	31.6 *(n/a)*	44.4 *(67)*	43.3 *(63)*	36.5 *(n/a)*	34.2 *(57)*	33.7 *(31)*	22.7 *(4)*	12.5 *(n/a)*	23.2 *(n/a)*
Poisons or has poisoned stock**	7.2 *(4)*	4.2 *(6)*	9.8 *(6)*	9.1 *(0)*	5.3 *(n/a)*	11.1 *(4)*	8.3 *(4)*	10.8 *(n/a)*	12.3 *(2)*	4.1 *(8)*	5.9 *(0)*	12.5 *(n/a)*	10.5 *(n/a)*
Causes poor growth of stock**	7.6 *(4)*	0 *(4)*	14.6 *(2)*	6.1 *(0)*	0 *(n/a)*	5.6 *(4)*	13.3 *(10)*	13.5 *(n/a)*	12.3 *(7)*	6.1 *(2)*	5.9 *(0)*	12.5 *(n/a)*	7.4 *(n/a)*
Competes with crops or pasture**	50.8 *(57)*	50 *(67)*	73.2 *(69)*	60.6 *(19)*	47.4 *(n/a)*	83.3 *(70)*	70 *(73)*	64.9 *(n/a)*	84.9 *(52)*	58.2 *(41)*	45.4 *(15)*	12.5 *(n/a)*	40 *(n/a)*
Prevents stock grazing amongst it**	22.3 *(30)*	33.3 *(33)*	22 *(46)*	21.2 *(6)*	21.1 *(n/a)*	44.4 *(43)*	33.3 *(40)*	23 *(n/a)*	39.7 *(24)*	25.5 *(18)*	20.2 *(4)*	12.5 *(n/a)*	15.8 *(n/a)*
Has the potential to rapidly get worse	69.2	87.5	56.1	60.6	89.5	66.7	71.7	82.4	74.0	86.7	84.9	100.0	87.4
In crops or pasture used for hay or silage**	14.6 *(24)*	8.3 *(46)*	17.1 *(29)*	12.1 *(17)*	0 *(n/a)*	27.8 *(30)*	20 *(40)*	17.6 *(n/a)*	13.7 *(12)*	23.5 *(43)*	17.6 *(4)*	0 *(n/a)*	14.7 *(n/a)*
Occurs in difficult terrain	25.5	25.0	19.5	24.2	36.8	11.1	26.7	35.1	28.8	29.6	32.8	37.5	32.6
Difficult to control	54.1	45.8	53.7	54.5	47.4	55.6	56.7	58.1	72.6	64.3	69.7	75.0	62.1
Other	11.2	20.8	12.2	12.1	5.3	0.0	8.3	16.2	4.1	17.3	21.0	12.5	8.4
n (2011 only)	*788*	*24*	*41*	*33*	*19*	*18*	*60*	*74*	*73*	*98*	*119*	*8*	*95*

** Overall survey response includes those who did not provide a post code*
*** Binomial test* ***for overall survey response only*** *p = 0*

Table 3.10: Reduction in pasture or crop productivity caused by fireweed in 'normal' and 'bad' fireweed years, as a percentage of respondents with fireweed 2011 (1985)

Reduction in productivity	'Normal' year*	'Bad' year**	n (2011 only)
None	45.3 (37)	37.2 (26)	345
0 - 10%	33.1 (44)	25.4 (33)	252
10 - 20%	16.3 (15)	21 (28)	124
20 - 50%	4.7 (4)	14.4 (12)	36
More than 50%	0.5 (0)	2 (1)	4

** Mann-Whitney U Test p = 0.096*
*** Mann-Whitney U Test p = 0.018*

Factors contributing to 'bad' fireweed years

The factors most likely to contribute to 'bad' fireweed years amongst respondents included poor fireweed control by neighbours (55.8 per cent), lack of time/labour/money to control fireweed effectively (43.8 per cent), and rainfall following drought (41.6 per cent) (Table 3.11). Within any particular region, the factors of most importance often vary depending on climatic, geographic and social differences.

Poor fireweed control by neighbours was considered a particularly significant factor in the Cumberland, Southern Inland NSW, Shoalhaven, Mid-North Coast and South-East Qld regions. This may reflect landscape fragmentation and growth in lifestyle farm subdivision around the major cities of Sydney, Wollongong and Brisbane, and high rates of population growth in the Mid-North Coast. Lack of time/labour/money was particularly significant in Lismore and the Mid-North Coast. Rainfall following drought appears more likely to contribute to 'bad' fireweed years in Southern Inland NSW, Bega, Gloucester and Muswellbrook. Despite evidence that sheep grazing is a relatively effective fireweed control technique in some circumstances, only 1.3 per cent of respondents indicated that a shift from sheep to cattle production contributed to a 'bad' year. This may be because within these regions not many landholders have traditionally been sheep farmers.

Respondents suggested other weather conditions and other factors that might contribute to a 'bad' fireweed year. Weather conditions noted by respondents include flood (including flood damage to pasture creating bare ground for fireweed infestation), drought, heavy rainfall in warmer weather (for example a warm wet summer), heavy rainfall seasons which did not allow herbicide application and which led to muddy bare areas in the paddock due to stock behaviour, and wind blowing the seed onto the property.

Other factors contributing to 'bad' years included bare or disturbed ground due to spraying, stock movement or wintering off of pasture species, absentee and

government neighbours not controlling the weed effectively, lack of knowledge and activity in the community regarding fireweed control, lack of pasture competition, poor grazing management (such as set stocking), mowing or slashing at the wrong time of season, and vehicles bringing seeds onto the property.

Other reasons fireweed is a problem

Respondents were given the opportunity to indicate other reasons fireweed was a problem on their property. Notable reasons included the cost, labour and time devoted to fireweed control by many farmers, impact on bushland and conservation areas on the property, impact on human health and the health of native and other animals as well as livestock, impact on relationships with neighbours, concerns over herbicide use, removing moisture and fertiliser from the soil, and inability to keep up with the pace of fireweed spread. Many of these are covered in Section 3.2.16).

Table 3.11: Factors contributing to a 'bad' fireweed year, as a percentage of respondents with fireweed 2011

		Survey regions											
	Overall survey*	**Cumberland**	**Hexham**	**Muswellbrook**	**Northern Tablelands/ NW Slopes**	**Gloucester**	**Taree/ Wauchope**	**Mid-North Coast**	**Lismore**	**Shoalhaven**	**Bega**	**Southern Inland NSW**	**South-East Qld**
Overgrazing of paddocks	23.0	3.7	34.2	44.4	16.7	52.6	36.9	34.2	38.2	12.1	26.9	0.0	18.7
Cultivation or spraying prior to sowing crop/pasture	11.4	0.0	10.5	3.7	27.8	47.4	18.5	13.7	23.7	14.1	11.8	0.0	2.2
Poor fireweed control by neighbours	55.8	85.2	47.4	44.4	44.4	26.3	66.2	76.7	38.2	82.8	66.4	83.3	68.1
Lack of time/labour/ money to control effectively	43.8	40.7	57.9	40.7	50.0	31.6	52.3	60.3	61.8	45.5	46.2	16.7	57.1
Shift from sheep to cattle production	1.3	0.0	0.0	11.1	16.7	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0
Rainfall after drought	41.6	48.1	57.9	66.7	33.3	68.4	29.2	34.2	43.4	39.4	64.7	83.3	50.5
Long term pasture deterioration	16.0	18.5	28.9	25.9	16.7	26.3	24.6	26.0	13.2	14.1	18.5	0.0	9.9
Hot dry summer + wet autumn	20.6	22.2	44.7	7.4	5.6	42.1	23.1	21.9	31.6	24.2	26.1	16.7	17.6
Cool moist summer + mild moist winter	12.2	14.8	10.5	11.1	0.0	5.3	10.8	24.7	18.4	17.2	16.0	0.0	6.6
n	*788*	*27*	*38*	*27*	*18*	*19*	*65*	*73*	*76*	*99*	*119*	*6*	*91*

** Overall survey response includes those who did not provide a post code*

3.2.7. Situations favouring growth

It appears that bare ground and heavily grazed pasture, where there is low pasture competition, are the most significant situations favouring the growth of fireweed on farms surveyed (Table 3.12). Likewise, more respondents thought low fertility compared with high fertility soils favoured fireweed growth, again presumably due to the relative lack of vigour in pastures on low fertility soils. However, over 36 per cent of respondents suggested that no particular situation favours fireweed growth, while the proportion of respondents nominating several of the situations favouring fireweed growth decreased significantly since the 1985 survey was conducted, according to the binomial test of significance. This suggests that landholder awareness of the situations favouring fireweed growth has increased as they have had to manage the weed over a longer time period. In the case of cultivated or burnt land favouring fireweed growth, decreases since 1985 may be a consequence of changed land management practices, where such methods have been less widely used over time. However, it is appropriate to conclude, as in the 1985 survey, that fireweed is an opportunistic weed with an ability to invade and colonise a wide range of habitats.

Of the other situations mentioned by respondents, the most common included degraded pastures, hilltops and slopes with a northerly, north-westerly, or easterly aspect or those facing the prevailing wind direction, roadsides and verges and along fencelines, and rocky and steep ground. A number of respondents stated that fireweed 'grows everywhere', while many also emphasised the importance of disturbed or bare ground as a highly suitable habitat for fireweed establishment.

Table 3.12: Situations favouring the growth of fireweed, as a percentage of respondents with fireweed 2011 (1985)

Situations favouring growth	***Percentage 2011 (1985)***
No particular situation	36.2 *(31)*
Previously cultivated land*	17.5 *(38)*
Previously burnt land	9.5 *(12)*
Native pasture*	14.8 *(32)*
Improved/fertilised pasture*	13.6 *(36)*
Heavily grazed pasture*	28.3 *(34)*
Soil of low fertility	20.3 *(23)*
Soil of high fertility*	8.5 *(16)*
Acid soil	9.5 *(n/a)*
Heavily limed soil	0.6 *(n/a)*
Bare ground*	32.1 *(24)*
Other	11.8 *(n/a)*

n = 788
** Binomial test p = 0*

3.2.8. Worst weed

Overall, just under 38 per cent of respondents considered fireweed to be their worst weed, compared with 43 per cent of respondents to the 1985 survey (Table 3.13). There were significant differences between regions regarding the issue, with those from Shoalhaven, Bega, Hexham, and the Mid-North Coast, significantly more likely to consider fireweed their worst weed than respondents from Muswellbrook, Lismore, Gloucester, Northern Tablelands/NW Slopes, and Taree/Wauchope. Fireweed is now considered the worst weed by a much higher proportion of respondents in Bega compared with 1985 (54 per cent compared with 6 per cent). It was considered the worst weed by a lower proportion of respondents in Gloucester and Taree/Wauchope in 2011 than it was in 1985. Data by post code also suggest that fireweed is less important than other weed species in parts of South-East Qld, Gloucester and Muswellbrook (Figure 3.5).

Other weeds of considerable importance overall (cited as amongst the most important weeds on respondents' properties) included lantana (*Lantana camara)*, blackberry (*Rubus fruticosus*), and giant Parramatta grass (*Sporobolus fertilis*) (Table 3.14). Miscellaneous thistles, broadleaf weeds, and grasses and sedges were also highly ranked. The five most commonly cited weeds other than fireweed for each region are also included in Table 3.14.

Although some bias towards ranking fireweed may occur in a survey specifically directed at fireweed, it was nevertheless considered the most important weed of pastures in all regions surveyed except the Northern Tablelands/NW Slopes (where it was ranked second behind blackberry), Taree/Wauchope and the Mid-North Coast (in both cases ranked second behind giant Parramatta grass), and Southern Inland NSW (ranked second behind serrated tussock).

Table 3.13: Fireweed as worst weed, as a percentage of respondents with fireweed 2011 (1985)

	Is fireweed your worst weed?		
Survey regions	**Yes**	**No**	***n (2011 only)***
Overall survey*	37.8 *(43)*	62.2 *(57)*	*739*
Cumberland	35.7 *(48)*	64.3 *(52)*	*28*
Hexham	43.2 *(46)*	56.8 *(54)*	*44*
Muswellbrook	22.2 *(8)*	77.8 *(92)*	*36*
Northern Tablelands/NW Slopes	24.0	76.0	*25*
Gloucester	22.2 *(54)*	77.8 *(46)*	*18*
Taree/Wauchope	27.1 *(77)*	72.9 *(23)*	*70*
Mid-North Coast	38.0	62.0	*79*
Lismore	24.1 *(36)*	75.9 *(64)*	*79*
Shoalhaven	54.8 *(51)*	45.2 *(49)*	*104*
Bega	54.0 *(6)*	46.0 *(94)*	*126*
Southern Inland NSW	37.5	62.5	*8*
South-East QLD	29.5	70.5	*122*

chisq = 48.3, d.f. = 11, p = 0

** Overall survey response includes those who did not provide a post code*

Table 3.14: Main weeds other than fireweed, ranked in order of importance 2011

	Other important weeds				
Survey regions	**Rank 1**	**Rank 2**	**Rank 3**	**Rank 4**	**Rank 5**
Overall survey*	Lantana (*Lantana camara*)	Blackberry (*Rubus fruticosus*)	Giant Parramatta grass (*Sporobolus fertilis*)	Spear thistle (*Cirsium vulgare*)	African lovegrass (*Eragrostis curvula*)
Cumberland	Blackberry (*Rubus fruticosus*)	Serrated tussock (*Nassella trichotoma*)	African lovegrass (*Eragrostis curvula*)	Spear thistle (*Cirsium vulgare*)	Fleabane (*Conzya spp.*)
Hexham	Lantana (*Lantana camara*)	Giant Parramatta grass (*Sporobolus fertilis*)	Blackberry (*Rubus fruticosus*)	Green cestrum (*Cestrum parqui*)	Spear thistle (*Cirsium vulgare*)
Muswellbrook	Blackberry (*Rubus fruticosus*)	Saffron thistle (*Carthamus lanatus*)	St John's wort (*Hypericum perforatum*)	Lantana (*Lantana camara*)	Bathurst burr (*Xanthium spinosum*)
Northern Tablelands/NW Slopes	Blackberry (*Rubus fruticosus*)	Nodding thistle (*Carduus nutans*)	St John's wort (*Hypericum perforatum*)	Saffron thistle (*Carthamus lanatus*)	Bracken fern (*Pteridium esculentum*)
Gloucester	Lantana (*Lantana camara*)	Blackberry (*Rubus fruticosus*)	Giant Parramatta grass (*Sporobolus fertilis*)	Wild tobacco (*Solanum mauritianum*)	Whiskey grass (*Andropogon virginicus*)
Taree/Wauchope	Giant Parramatta grass (*Sporobolus fertilis*)	Lantana (*Lantana camara*)	Crofton weed (*Ageratina adenophora*)	Wild tobacco (*Solanum mauritanum*)	Bracken fern (*Pteridium esculentum*)
Mid-North Coast	Giant Parramatta grass (*Sporobolus fertilis*)	Lantana (*Lantana camara*)	Blackberry (*Rubus fruticosus*)	Privet (*Ligustrum spp.*)	Smartweed (*Persicaria decipiens*)
Lismore	Lantana (*Lantana camara*)	Giant Parramatta grass (*Sporobolus fertilis*)	Camphor laurel (*Cinnamomum camphora*)	Crofton weed (*Ageratina adenophora*)	Spear thistle (*Cirsium vulgare*)
Shoalhaven	Blackberry (*Rubus fruticosus*)	Lantana (*Lantana camara*)	Giant Parramatta grass (*Sporobolus fertilis*)	Spear thistle (*Cirsium vulgare*)	Serrated tussock (*Nassella trichotoma*)
Bega	Blackberry (*Rubus fruticosus*)	African lovegrass (*Eragrostis curvula*)	Serrated tussock (*Nassella trichotoma*)	Paterson's curse (*Echium plantagineum*)	Lantana (*Lantana camara*)
Southern Inland NSW	Serrated tussock (*Nassella trichotoma*)	Nodding thistle (*Carduus nutans*)	Fleabane (*Conzya spp.*)	Saffron thistle (*Carthamus lanatus*)	Paterson's curse (*Echium plantagineum*)
South-East QLD	Lantana (*Lantana camara*)	Spear thistle (*Cirsium vulgare*)	Ragweed (*Ambrosia artemisiifolia*)	Bathurst burr (*Xanthium spinosum*)	Noogoora burr (*Xanthium occidentale*)

** Overall survey response includes those who did not provide a post code*

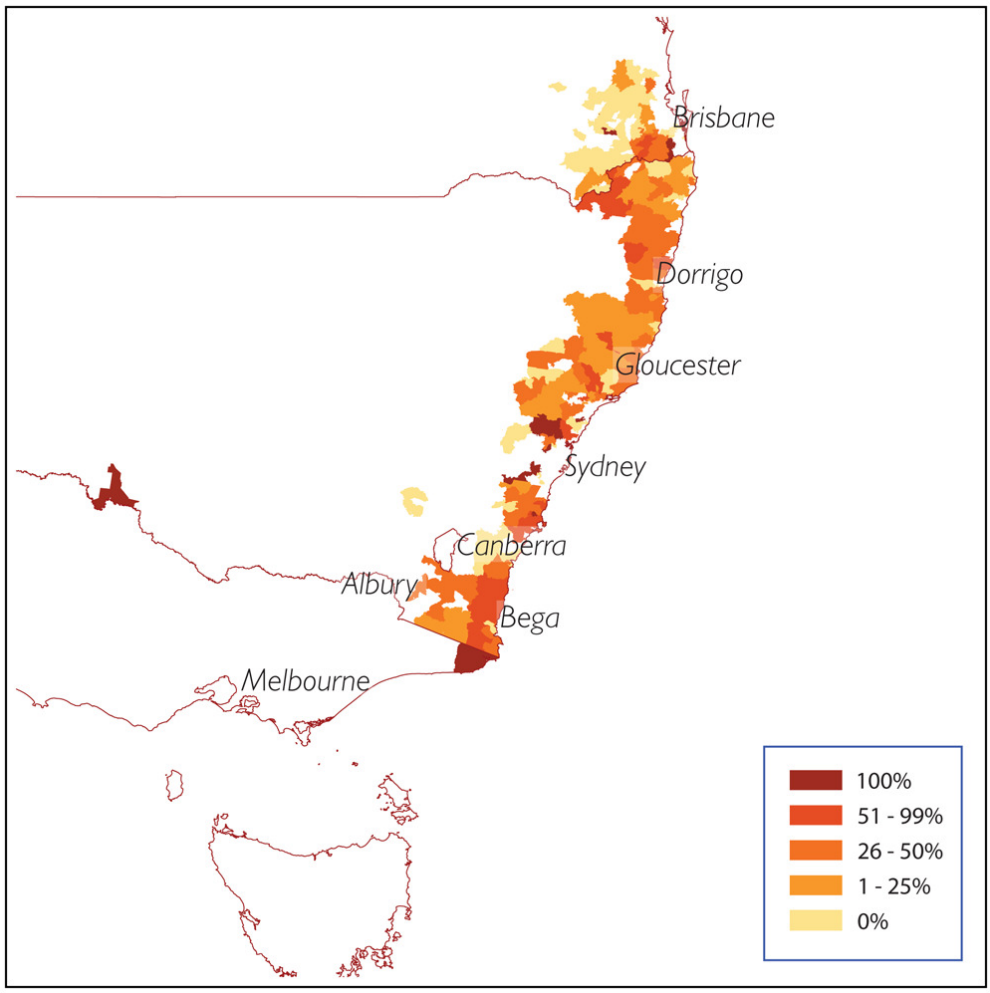

Figure 3.5: Proportion of respondents who consider fireweed their worst weed, by post code

3.2.9. Comparison between dairying, beef and sheep grazing properties

There was little appreciable difference in the occurrence of fireweed as perceived by respondents on dairying and beef grazing properties. However, sheep producers were significantly less likely to have large or moderate fireweed infestations on their property (Table 3.15).

Likewise there was no significant difference between dairy and beef producers regarding the perceived size of the fireweed problem, although sheep producers were once again significantly less likely to consider fireweed a moderate or major problem (Table 3.16). These results suggest that sheep may be useful in managing fireweed infestations, and that those who focus on sheep production therefore are less likely to consider fireweed an important land management issue (see also page 58).

Table 3.15: Relationship between farm enterprise type and fireweed occurrence on property, as a percentage of respondents 2011

	Does fireweed occur on your property?				
Main property enterprise	Yes – small amount	Yes – moderate amount	Yes – large amount	Yes – but has been controlled	n
Dairying	33.0	37.6	14.7	14.7	109
Beef cattle	26.4	42.7	18.3	12.6	459
Sheep	60.6	15.2	6.1	18.2	33
Goats	40.0	13.3	20.0	26.7	15
Other	50.7	30.0	8.0	11.3	150

chisq = 52.9, d.f. = 12, p = 0

Table 3.16: Relationship between farm enterprise type and size of the fireweed problem, as a percentage of respondents 2011

	Size of the fireweed problem as perceived by farmers				
Main property enterprise	No problem	Minor problem	Moderate problem	Major problem	n
Dairying	12.0	37.0	34.3	16.7	109
Beef cattle	8.9	33.7	36.5	20.9	460
Sheep	26.5	58.8	11.8	2.9	34
Goats	35.7	21.4	35.7	7.1	14
Other	20.4	50.0	20.4	9.2	152

chisq = 63.9, d.f. = 12, p = 0

Sheep producers were significantly less likely than beef producers to consider fireweed as having contributed to stock poisoning (1.6 per cent and 9.6 per cent respectively) and poor stock growth (3.1 per cent and 10.2 per cent respectively). A high proportion of both dairy and beef producers believed fireweed was competing with crops or pasture on their land (49.3 per cent and 57.5 per cent) compared with a much lower proportion of sheep producers (7.8 per cent), again suggesting that fireweed is a less significant issue for sheep producers.

Presence of fireweed in hay or pasture used for silage was of greater concern amongst dairy farmers (27.5 per cent) than beef producers (14.2 per cent). However, beef producers (67.3 per cent) were more likely than dairy farmers (47.2 per cent) to believe that fireweed was of concern given its potential to rapidly get worse.

Notably, a majority (56.3 per cent) of beef producers considered fireweed difficult to control than either dairy (40.1 per cent) or sheep producers (21.9 per cent).

Of situations said to favour fireweed growth, improved pasture, heavily grazed pasture and bare ground were considered important by a higher proportion of beef producers than either dairy or sheep producers (Table 3.17). Thus it appears that on beef grazing properties, where vigorous pastures are less likely to be grown than on dairy farms, soil disturbance and exposure is more likely to allow fireweed to thrive. Likewise, the process of improving pastures, whether

by spraying herbicide or cultivation combined with resowing, or fertiliser application (to which fireweed responds) is also likely to lead to an outbreak of fireweed on beef cattle properties where there is likely to be high populations of fireweed seeds in the soil. Although sheep producers may adopt many of the same pasture management techniques as beef graziers, the evidence that sheep control fireweed with some effectiveness (page 58) means that bare ground may be less likely to lead to a significant outbreak of fireweed, presumably because of a relative lack of fireweed seed in the soil seed bank. These data suggest that in dairy pastures, which are generally improved and often more competitive than beef pastures, fireweed is only likely to thrive where there is reduced pasture cover under heavy grazing or bare ground.

Table 3.17: Relationship between farm enterprise type and size of the fireweed problem, as a percentage of respondents 2011

	Situations favouring fireweed growth on the property		
Main property enterprise	**Improved/ fertilised pasture***	**Heavily grazed pasture****	**Bare ground†**
Dairying	7.0	19.7	28.2
Beef cattle	16.8	32.1	33.1
Sheep	0	4.7	7.8
Goats	17.6	0	17.6
Other	5.1	17.9	23.7

** chisq = 30.7, d.f. = 4, p = 0*
*** chisq = 39.3, d.f. = 4, p = 0*
† chisq = 21.3, d.f. = 4, p = 0

3.2.10. Control

As was the case in 1985, over 80 per cent of respondents attempt to control fireweed using one or more methods. Those in the Gloucester and Muswellbrook regions were least likely to attempt to control the weed, while those from Shoalhaven (where there has been an active promotion of fireweed control at Council level for a number of years) were the most likely to attempt fireweed control (Table 3.18). Respondents operating all enterprise types were highly likely to control fireweed if it was present on their farm, although sheep graziers (nearly 94 per cent) and those operating an 'other' form of enterprise (over 93 per cent) were somewhat more likely to attempt to control fireweed than beef graziers (81 per cent) or dairy farmers (80 per cent).

Respondents were given the option to indicate that they used to control fireweed but no longer do so. Under this category, the highest response was received from the Gloucester, Lismore and Muswellbrook regions. In these regions, fireweed had been present for a longer period (Table 3.3), and was considered a minor or moderate problem by a high proportion of respondents (Table 3.5). Familiarity with the weed and improved land management practices (such as maintaining healthy pasture) may mean that some respondents no longer feel the need to control fireweed, while for others, different weeds may have taken priority (Table 3.13).

Table 3.18: Whether fireweed control is attempted, as a percentage of respondents with fireweed 2011

	Do you attempt to control fireweed?			
Survey regions	Yes	No	Used to control fireweed	*n*
Overall survey	83.6	4.5	11.9	*750*
Cumberland	93.1	0.0	6.9	*29*
Hexham	75.6	8.9	15.6	*45*
Muswellbrook	60.0	20.0	20.0	*35*
Northern Tablelands/NW Slopes	83.3	8.3	8.3	*24*
Gloucester	60.0	10.0	30.0	*20*
Taree/Wauchope	82.9	10.0	7.1	*70*
Mid-North Coast	91.2	0.0	8.8	*80*
Lismore	65.9	11.0	23.2	*82*
Shoalhaven	97.2	0.9	1.9	*107*
Bega	85.9	0.0	14.1	*128*
Southern Inland NSW	87.5	0.0	12.5	*8*
South-East QLD	87.7	1.6	10.7	*122*

chisq = 91.0, d.f. = 22, p = 0

Common reasons given for no longer attempting to control fireweed included:

- being impossible to control and therefore a 'losing battle';
- not worthwhile when neighbours were not controlling fireweed on their properties;
- control measures used being ineffective;
- cost of control outweighing the benefits and eating into farm profits too significantly;
- age and health;
- lack of money or time;
- the weed was no longer a major problem; and
- dislike of chemicals.

The most common reason for no longer attempting to control fireweed was the perception that it was impossible to bring under control. Analysis suggested that those who consider fireweed to be a moderate or major problem on their property were significantly more likely to have given up on fireweed control than those who consider it a minor problem, or no problem at all.

Those who indicated that they did attempt to control fireweed were asked to list the method or methods used for control. These, and their relative success, are included in Table 3.19.

Table 3.19: Use and success of fireweed control methods, as a percentage of respondents with fireweed 2011 (1985)

Control method	Level of use (n = 663)*	Level of success**			
		Low	Mod	High	n (2011 only)
Hand weeding†	81.3 (74)	19.1 (37)	27.7 (29)	53.2 (34)	*570*
Slashing†	35.9 (68)	30.5 (41)	56.2 (46)	13.3 (13)	*274*
Cultivation†	3.8 (19)	18.2 (33)	63.6 (54)	18.2 (13)	*62*
Herbicides†	37.6 (12)	11.7 (22)	47.3 (37)	41 (41)	*259*
Grazing with sheep or goats†	10.7 (5)	11.9 (11)	34.3 (22)	53.7 (67)	*78*
Reduced stocking rates	8.7 (n/a)	27.8 (n/a)	50 (n/a)	22.2 (n/a)	*82*
Promoting competitive pasture	35.1 (35)	15.5 (21)	52.2 (37)	32.4 (42)	*234*
Other	6 (n/a)	6.9 (n/a)	27.6 (n/a)	65.5 (n/a)	*33*

** Percentage of respondents who attempt fireweed control.*
*** Percentage of respondents who attempt control by that method.*
† *Binomial test p = 0*

Hand weeding

Hand weeding remains by a large margin the most widely used fireweed control method amongst respondents, and its use has increased significantly since 1985 according to the binomial test. It is also considered to be one of the more successful methods.

Hand weeding is impractical for many farmers, particularly those on larger farms with large weed infestations, as it is very time-consuming and labour-intensive. Nevertheless, in the more closely settled coastal regions of NSW and South-East Qld, hand weeding appears to be still widely practised, and plays a significant role in fireweed control. It is particularly useful for smaller outbreaks of fireweed on farms of all sizes, on rural-residential blocks of about 1 hectare or less, or as an alternative to spot spraying for control of mature plants that were not controlled successfully by boom-applied selective herbicide. One respondent commented '[hand weeding] is not practical on large areas. I only use this in small areas like cattle yards'.

Hand weeding is more common amongst respondents who operate 'other' enterprises including a small-scale hobby, conservation, lifestyle or subsistence farming enterprise (88 per cent) than those who run a commercial dairy (46 per cent), beef (65 per cent) or sheep grazing (41 per cent) enterprise. Respondents were significantly more likely to use hand weeding to control fireweed if they only had a small amount of fireweed on their property (85 per cent), or if they considered the weed to have been controlled (81 per cent). At the same time, these respondents were more likely to consider hand weeding a highly successful method (67 per cent and 66 per cent respectively, compared to an overall response for this method of 53 per cent (Table 3.19).

Respondents from the Cumberland, South-East Qld, Shoalhaven, and Muswellbrook regions were more likely to use hand weeding than those from Hexham, Gloucester or Lismore, which have all had fireweed for a longer period of time (Figure 3.6).

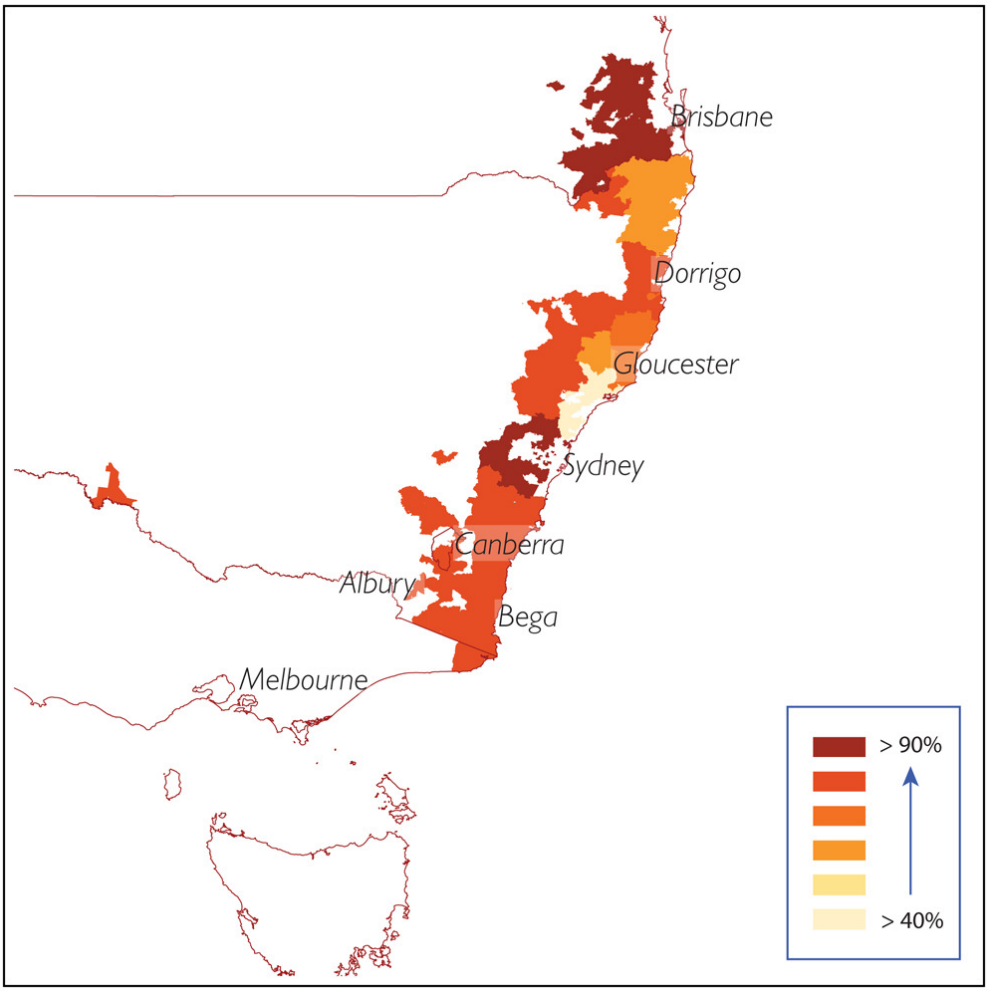

Figure 3.6: Hand weeding use – percentage of those who attempt to control fireweed, by region

Herbicides

Larger outbreaks of fireweed may best be sprayed with a registered selective herbicide using a vehicle mounted 'boom' applicator or 'wick wiper', however as some respondents noted, pasture damage can result from broad application, particularly of a non-selective herbicide.

The overall rate of herbicide use for fireweed control has increased significantly over time, with 37.6 per cent of respondents indicating they use the method, compared with only 12 per cent of respondents to the 1985 survey.

Herbicides were assessed as giving either moderate or high success in control by nearly 90 per cent of respondents who use this method. Significantly, it was a favoured method by many respondents who have either moderate (48 per cent) or large (66 per cent) amounts of fireweed on their property, circumstances under which the cost-effectiveness and efficiency of herbicide application may be favoured.

Herbicides are more frequently used for fireweed control in the Cumberland, Mid-North Coast, South-East Qld, and Shoalhaven regions, and are a less favoured approach in Gloucester, Taree/Wauchope and Bega (Figure 3.7).

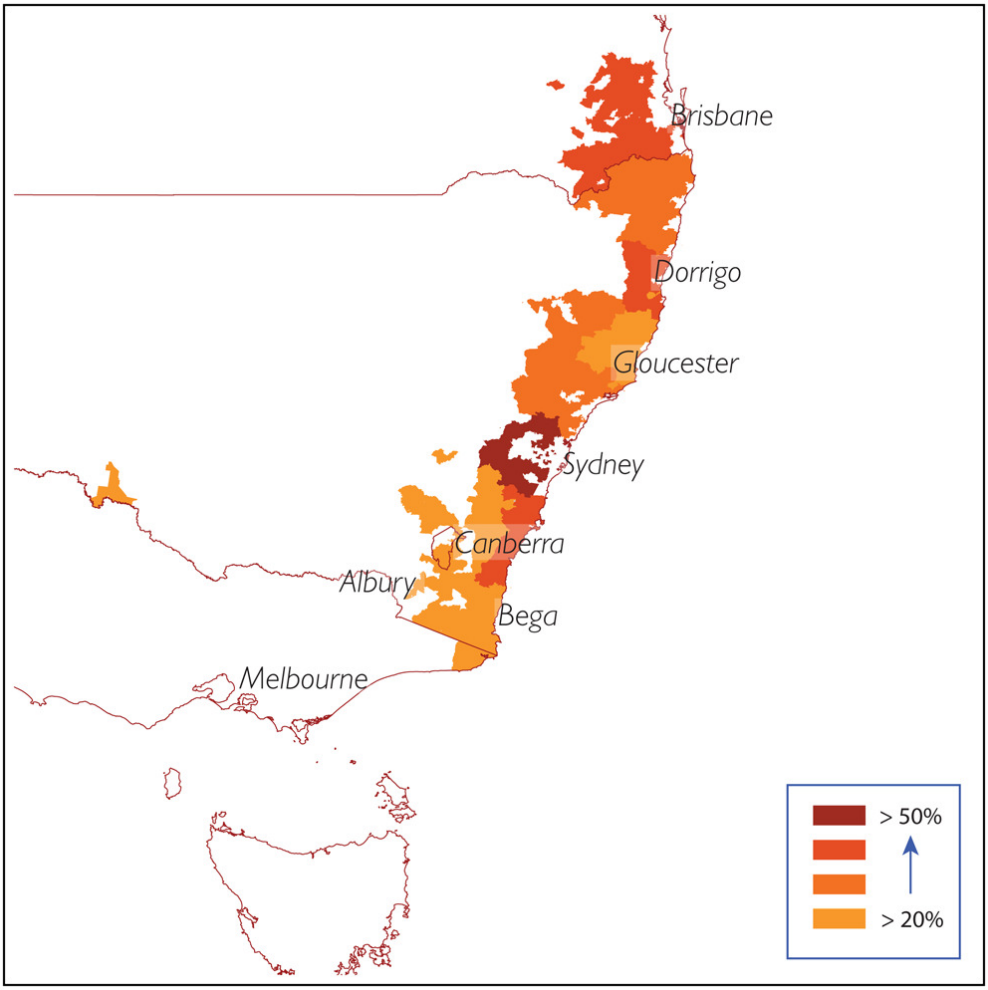

Figure 3.7: Herbicide use – percentage of those who attempt to control fireweed, by region

Slashing and cultivation

Overall, the use of slashing has declined significantly over time, with nearly 36 per cent of respondents using this method compared with 68 per cent in 1985. This is not surprising given that the method is rated as having a low level of success by over 30 per cent of respondents who used the method in 2011 (Table 3.19).

Current best practice suggests that slashing has a number of drawbacks if not carried out correctly, such as spreading seed from flowering plants, although it may assist farmers in controlling dense infestations if it can be done before flowering. Respondents who have used slashing with some success noted that regular follow-up slashing is required to minimise flowering and seed-set of fireweed plants.

A number of respondents commented on the drawbacks of slashing, suggesting that it can make the fireweed problem worse if carried out at the wrong time. One commented that 'slashing causes [fireweed] to seed and also reduces competition, therefore increases fireweed'. Another stated 'after seeing the adjacent neighbour slash his one acre of weed and next year seeing not only me but two other adjacent blocks with it I would like to present a case for no slashing please'.

Cultivation was considered a relatively unsuccessful control method, and is a much less common method than slashing. It was only used by a small proportion of respondents, and its use declined sharply since the 1985 survey.

Cultivation is not recommended as a fireweed control method as it generally stimulates fireweed seed germination and results in an increase in the density of fireweed (Sindel and Coleman 2011).

Competitive pastures

Competitive pastures were considered to be as effective in controlling fireweed as herbicides, and the method was as widely used amongst respondents. While promoting competitive pasture is a longer term control method for fireweed, it appears that the use of this method had not increased since the first survey was conducted in 1985. Greater uptake of this method should give farmers ongoing fireweed control benefits, particularly as it was noted in this survey that overgrazing and bare ground favour fireweed establishment and contribute significantly to 'bad' fireweed years.

Farmers with moderate (38.5 per cent) or large (47 per cent) amounts of fireweed on their property, as well as those who considered fireweed to be under control on their property (39 per cent), were more likely to promote competitive pastures for fireweed control compared with those who only had a small infestation (21 per cent). Those with high infestations were also somewhat more likely to consider the method unsuccessful (45 per cent of respondents with a small amount of fireweed on their property, compared to 32 per cent overall (Table 3.19).

Dairy farmers were more likely to use pasture competition for fireweed control than beef or sheep graziers. Farmers from Gloucester, Lismore and the Mid-North Coast, all areas with relatively high rainfall, were the most likely to employ the method.

As one respondent noted 'competition [from] other plants seems to be the most cost effective method, especially setaria on poorer country. Combining hand pulling and competitive pasture growth is also effective'.

A number of pasture species were noted by respondents to compete well with fireweed, including Rhodes grass (*Chloris gayana*), setaria (*Setaria sphacelata*), Kikuyu (*Pennisetum clandestinum*), white clover (*Trifolium repens*), microlaena (*Microlaena stipoides*), and buffalo grass (*Stenotaphrum secundatum*). The competitiveness of specific pasture species with fireweed is discussed in more detail in section 3.2.11.

Although it is integral to developing a competitive pasture on farms, reducing stocking rates to control fireweed was employed by just under 9 per cent of respondents overall, with just over 20 per cent considering this method highly successful. This may suggest that many landholders try to maintain a balance between effective weed control and maximising livestock turnover and therefore economic productivity.

Respondents with moderate to high fireweed infestations, as well as those who considered fireweed to be a major problem, were more likely to reduce stocking rates than those with only a small infestation, or who consider fireweed to be a minor problem. Beef producers were more likely to reduce stocking rates than dairy farmers.

Grazing with sheep or goats

Sheep and goats may be of some use in fireweed control, as they readily eat fireweed and are some 10-20 times less susceptible to poisoning than cattle and horses (Sindel and Coleman 2011). Respondents indicated that sheep or goats control most but not all fireweed plants.

While this was considered to be the most successful fireweed control method overall, just over 10 per cent of respondents used sheep or goats to graze fireweed on their property. Notably, however, the proportion of landholders using the method since the 1985 survey was conducted has increased by a significant margin. This may be due in part to the focus of the 1985 survey being on dairy and beef graziers.

When only non-sheep or goat producers who participated in the survey were taken into account, only 2.7 per cent of dairy producers who attempted to control fireweed, and 7.8 per cent of beef producers, used this method to control fireweed. When compared with the dairy- and beef grazier-focussed 1985 survey, where the method was found to be used by 5 per cent of respondents overall, there may not have been a significant increase in overall use of this method for controlling fireweed. However as with other producers, the large majority of beef graziers and dairy farmers using this method in 2011 rated it as either highly or moderately successful.

The method was in relative widespread use in Bega (over 30 per cent of respondents), and was used by 12.1 per cent of those from Taree/Wauchope, and 9.1 per cent from Muswellbrook. Few or no respondents from the Cumberland, Lismore, Mid-North Coast and South-East Qld regions grazed with sheep or goats, perhaps due the type of management they require, and the type of landscape to which they are most suited. Sheep and goats often require improved fencing, and changes to farm infrastructure such as sheep shearing facilities and possibly modified stock yards.

Other

Respondents were given the opportunity to list other methods they used to control fireweed. Some common responses included:

- soil improvement;
- mulching;
- bagging and burning plants removed by hand;
- using fire to burn off pastures infested with fireweed;
- using intensive (cell) or rotational grazing; and
- planting trees to shade out the weed.

While many respondents did not rate the level of success of other methods used, many who improved the soil suggested that they had achieved a high level of success with this method, using fertilisers or applying lime to correct the soil pH. One respondent commented that improving the soil condition renders fireweed uncompetitive with pasture species.

A few respondents had taken up mulching, with one commenting 'Mulching is far superior to slashing as you get no windrow maturation of seedheads. It also promotes an even and dense pasture sward.'

Several indicated that they used fire to burn areas infested with fireweed, though the success of this approach appears to have been variable. A number of respondents also noted that they bagged fireweed plants and burnt them to destroy seeds.

3.2.11. Pasture species for control

Respondents were asked to evaluate a range of pasture species regarding their ability to control fireweed growth (Table 3.20). Overall, kikuyu was considered to be the best species for fireweed control (37.8 per cent), followed by ryegrass (14.7 per cent), paspalum (11.2 per cent) and white clover (10.2 per cent).

The relative usefulness of particular species varied between regions and situations. For example, kikuyu was considered effective by a much higher proportion of respondents in Hexham, Muswellbrook and Lismore than it was in the Northern Tablelands/NW Slopes, Southern Inland NSW and South-East Qld, and was more likely to be effective on dairy farms than beef or sheep grazing. Likewise, ryegrass appears more useful in Muswellbrook and Gloucester than in Southern Inland NSW, South-East Qld and Lismore, and is most useful to dairy farmers.

Species like setaria seem to have been promoted in certain regions such as Hexham, Gloucester, Taree/Wauchope and Lismore. This is reflected by their increased effectiveness in these regions since 1985 (Table 3.20).

While kikuyu is still considered overall to be the best pasture species for fireweed control, it is notable that the proportion of respondents favouring this species declined significantly from 60 per cent in 1985 to 37.8 per cent in 2011. This reduced rating is particularly notable in the Gloucester and Cumberland

regions, and also appears to be influenced by the inclusion of new regions in the 2011 survey, regions where kikuyu received a low rating and where kikuyu pasture may be less prevalent due to local climatic conditions. Nonetheless, kikuyu appears to be increasingly favoured for its fireweed control ability in Muswellbrook, Hexham, Shoalhaven and Bega. The pasture species best able to compete with fireweed is dependent on region.

Table 3.20: Pasture species found to best control fireweed, as a percentage of respondents with fireweed 2011 (1985)

		Survey regions											
	Overall survey*	**Cumberland**	**Hexham**	**Muswellbrook**	**Northern Tablelands/ NW Slopes**	**Gloucester**	**Taree/ Wauchope**	**Mid-North Coast**	**Lismore**	**Shoalhaven**	**Bega**	**Southern Inland NSW**	**South-East Qld**
None	29.6 *(25)*	47.8 *(18)*	10.5 *(2)*	22.6 *(50)*	68.4 *(n/a)*	22.2 *(2)*	26.3 *(23)*	28.4 *(n/a)*	25 *(37)*	37.1 *(43)*	41.8 *(53)*	50 *(n/a)*	55.4 *(n/a)*
Phalaris	4.1 *(3)*	21.7 *(10)*	2.6 *(2)*	9.7 *(0)*	5.3 *(n/a)*	11.1 *(2)*	1.8 *(2)*	3 *(n/a)*	0 *(0)*	3.1 *(0)*	10 *(0)*	25 *(n/a)*	1.1 *(n/a)*
Ryegrass	14.7 *(17)*	21.7 *(26)*	18.4 *(19)*	32.3 *(4)*	15.8 *(n/a)*	33.3 *(37)*	28.1 *(29)*	23.9 *(n/a)*	11.1 *(20)*	23.7 *(18)*	13.6 *(0)*	0 *(n/a)*	6.5 *(n/a)*
White clover	10.2 *(14)*	21.7 *(26)*	18.4 *(27)*	25.8 *(0)*	10.5 *(n/a)*	33.3 *(24)*	10.5 *(19)*	16.4 *(n/a)*	6.9 *(10)*	13.4 *(14)*	13.6 *(0)*	0 *(n/a)*	2.2 *(n/a)*
Sub clover**	3.2 *(8)*	13 *(22)*	2.6 *(21)*	16.1 *(0)*	5.3 *(n/a)*	0 *(17)*	1.8 *(6)*	1.5 *(n/a)*	0 *(0)*	7.2 *(5)*	4.5 *(0)*	0 *(n/a)*	1.1 *(n/a)*
Kikuyu**	37.8 *(60)*	34.8 *(54)*	81.6 *(77)*	67.7 *(21)*	10.5 *(n/a)*	50 *(91)*	54.4 *(65)*	50.7 *(n/a)*	56.9 *(59)*	50.5 *(39)*	39.1 *(18)*	25 *(n/a)*	29.3 *(n/a)*
Paspalum	11.2 *(11)*	4.3 *(16)*	36.8 *(10)*	32.3 *(4)*	0 *(n/a)*	38.9 *(15)*	15.8 *(10)*	25.4 *(n/a)*	22.2 *(12)*	4.1 *(2)*	0.9 *(0)*	0 *(n/a)*	9.8 *(n/a)*
Rhodes grass**	6.1 *(3)*	0 *(0)*	10.5 *(2)*	6.5 *(0)*	0 *(n/a)*	11.1 *(0)*	7 *(4)*	10.4 *(n/a)*	19.4 *(0)*	1 *(0)*	0 *(0)*	0 *(n/a)*	15.2 *(n/a)*
Setaria**	9.4 *(3)*	0 *(0)*	15.8 *(0)*	0 *(0)*	0 *(n/a)*	22.2 *(0)*	26.3 *(4)*	28.4 *(n/a)*	38.9 *(15)*	0 *(0)*	0 *(0)*	0 *(n/a)*	2.2 *(n/a)*
Other	11.2 *(n/a)*	21.7 *(n/a)*	2.6 *(n/a)*	12.9 *(n/a)*	10.5 *(n/a)*	33.3 *(n/a)*	8.8 *(n/a)*	10.4 *(n/a)*	13.9 *(n/a)*	12.4 *(n/a)*	20 *(n/a)*	0 *(n/a)*	15.2 *(n/a)*
n (2011 only)	*788*	*23*	*38*	*31*	*19*	*18*	*57*	*67*	*72*	*97*	*110*	*4*	*92*

** Overall survey response includes those who did not provide a post code*
*** Binomial test* ***for overall survey response only*** *p = 0*

3.2.12. Control success

Those who had successfully reduced the area or intensity of fireweed on their property were asked to indicate how they had achieved this. Three methods were important to the successful fireweed control strategy; removing weeds by hand, promoting competitive pasture, and using herbicides (Table 3.21). Removing weeds by hand was the most widely used single fireweed control method, with many respondents acknowledging that the method is time consuming and requires continual attention in order to assure success. Some respondents remove plants by hand to control fireweed on specific parts of the property only. Others pointed out that the method is easier to employ when the ground is moist. Hand weeding is somewhat more likely to be favoured by respondents in South-East Qld, Southern Inland NSW and the Northern Tablelands/NW Slopes, where the scale of the problem was considered relatively minor by respondents (Table 3.5), suggesting that hand weeding is more practical for small-scale outbreaks.

Healthy pastures were encouraged through application of fertiliser and lime, and promotion of native and introduced pasture species. Pasture cover was associated by many with reduced fireweed populations, while poor quality pasture (for example as a result of over grazing) resulted in rapid fireweed spread. Many respondents combined grazing management strategies (such as rotational or cell grazing) with pasture improvement activity to maximise dense pasture coverage. One respondent summarised their approach as follows:

> *Improving fertility of soils, with use of lime, superphosphate and chicken litter. Planting improved pasture seeds including setaria, kikuyu, rhodes, and clover, in an attempt to generate greater ground cover, thus reducing the opportunity for fireweeed to germinate. The propertie s(2-one 12ha, the other 100ha) have been subdivided into many paddocks so that stock can be rotationally grazed.*

Pasture competition was found to be a more popular method amongst dairy farmer respondents than hand pulling, perhaps a consequence of the goal of many dairy farmers to grow improved pastures as part of their normal operations.

It is important to note however that weed control methods are often employed together as part of a successful integrated approach to controlling fireweed. Of the respondents who had reduced the area/intensity of fireweed on their farm, 27 per cent indicated they had employed an integrated approach using two or more of the specific methods listed in Table 3.21. Common integrated techniques included:

- hand weeding and herbicide;
- herbicide use and improved pasture competition;
- hand weeding and slashing; and
- hand weeding and improved pasture competition.

Often, respondents successfully combined 'weed removing' techniques such as hand weeding or herbicides with 'pasture improving' techniques such as application of fertiliser or reduced stocking rates.

In addition to the weed control methods adopted successfully, respondents mentioned general approaches to fireweed control which allowed them to reduce fireweed on their property. Top amongst these was a willingness to remain vigilant (Table 3.21). Vigilance involved continuously or regularly monitoring for fireweed (for example when completing other property management tasks), controlling outbreaks as soon as they were identified, and regularly rechecking previous infestation areas:

> *I am vigilant in pulling out weeds and burning them. I regularly do this. When I moved here there was a lot more fireweed than there is now on my property. Now I am just dealing with what blows across from neighbours properties, as the fireweed generally occurs around the perimeter of my place.*

Vigilance also involved several years of hard work on the part of farmers, before the seed bank was reduced to the extent that they start to observe the benefits. As one respondent commented:

> *Areas which are picked daily/monthly for the last 5 years have low levels of fireweed. If areas are not picked regularly each season/year then the growth/amount of fireweed returns back to a moderate level in the next and subsequent seasons.*

Table 3.21: How the area/intensity of fireweed was successfully reduced on respondent properties (multiple response)

How the area/intensity of fireweed was successfully reduced on respondent properties	Percentage
Pulling out by hand	44.3
Vigilance: regular and immediate monitoring and control	24.8
Promoting competitive pasture	22.2
Herbicides	18.9
Slashing and mulching	13.7
Reduced stocking rates	9.3
Grazing with sheep or goats	7.8
Systematic control (e.g. one paddock at a time)	3.0
Other control methods	2.6
Control before flower/set seed	2.2
Integrated fireweed management unspecified	2.0
Work with neighbours/Landcare groups	1.1

n = 704

3.2.13. Economics of control

Nearly half of respondents estimated that they spend over 50 hours each year controlling fireweed on their property, while nearly 40 per cent estimated they spent $1,000 or more on control activity (Table 3.22).

More than 50 per cent of respondents from Hexham, Gloucester, the Mid-North Coast, Lismore and Bega spent over 50 hours annually controlling fireweed. Likewise 50 per cent of respondents in Shoalhaven, Southern Inland NSW, and over 40 per cent from Bega and Hexham, spent more than $1,000 on fireweed control annually (Figure 3.8 and Figure 3.9).

Sheep and goat producers spent significantly less time and money on fireweed control activity than their dairying or beef grazing counterparts, suggesting that sheep and goats offer 'free' and relatively effective control for these producers (see also page 58).

Similarly, of the weed control methods, farmers using grazing with sheep or goats or hand weeding as part of their fireweed control strategy spent the least time and money overall. While hand weeding may be considered the most time-consuming of the fireweed control methods available, its relationship with less time spent on fireweed control in this survey may relate to its importance for those with smaller infestations, or owners of small acreage properties. In both these cases, hand weeding is a more feasible control option (page 54). Those who reduced stocking rates spent the most time on control, while those using cultivation spent the most money. Herbicides and pasture competition were the next most costly methods overall.

As expected, the larger the amount of fireweed on property, the more time and money is spent on control activity. However, it is notable that of those who consider fireweed to be under control on their property, approximately 50 per cent spend more than 50 hours and more than $1,000 per year on control activity, suggesting that maintaining fireweed at a controllable level on farm can be a significant cost to farmers in time and money.

Table 3.22: Time and money spent on fireweed control, as a percentage of respondents who attempted fireweed control

Time spent controlling fireweed		***Money spent controlling fireweed***	
Time *(hours/year)*	**Percentage**	**Money *($/year)***	**Percentage**
0 - 25	30.6	0 - 200	33.1
25 - 50	23.5	200 - 1,000	29.4
50 - 100	24.7	1,000 - 5,000	25.9
100 - 500	16.8	5,000 - 10,000	7.7
More than 500	4.4	More than 10,000	4.0

As with the question on the scale of the fireweed problem, responses regarding the amount of time and money spent were coded, and mean scores produced for each post code where a response was received for the post code. A mean score between two categories was recoded to match the closest categorical whole number score. For example, where '1' refers to '0 – 25 hours/year', and '2' refers to '25 – 50 hours/year', a mean score of 1.49 was coded as 0 – 25 hours/year, and a mean score of 1.50 as 25 – 50 hours/year. The results are presented in Figure 3.8 (mean time spent by post code) and Figure 3.9 (mean money spent by post code).

The data indicate that relatively more time and money is spent on fireweed control along much of the coastal and hinterland regions of NSW, particularly around Bega, Shoalhaven, Dorrigo, and Lismore. Respondents from the more inland regions of NSW, and parts of South-East Qld, appear to spend less time and money controlling fireweed. Some correlation between these figures and Figure 3.4 (the extent of the fireweed problem) may be observed in broad terms, where the more significant the problem (Figure 3.4), often as a result of recent spread, the greater the amount of time and money spent (Figure 3.8 and Figure 3.9).

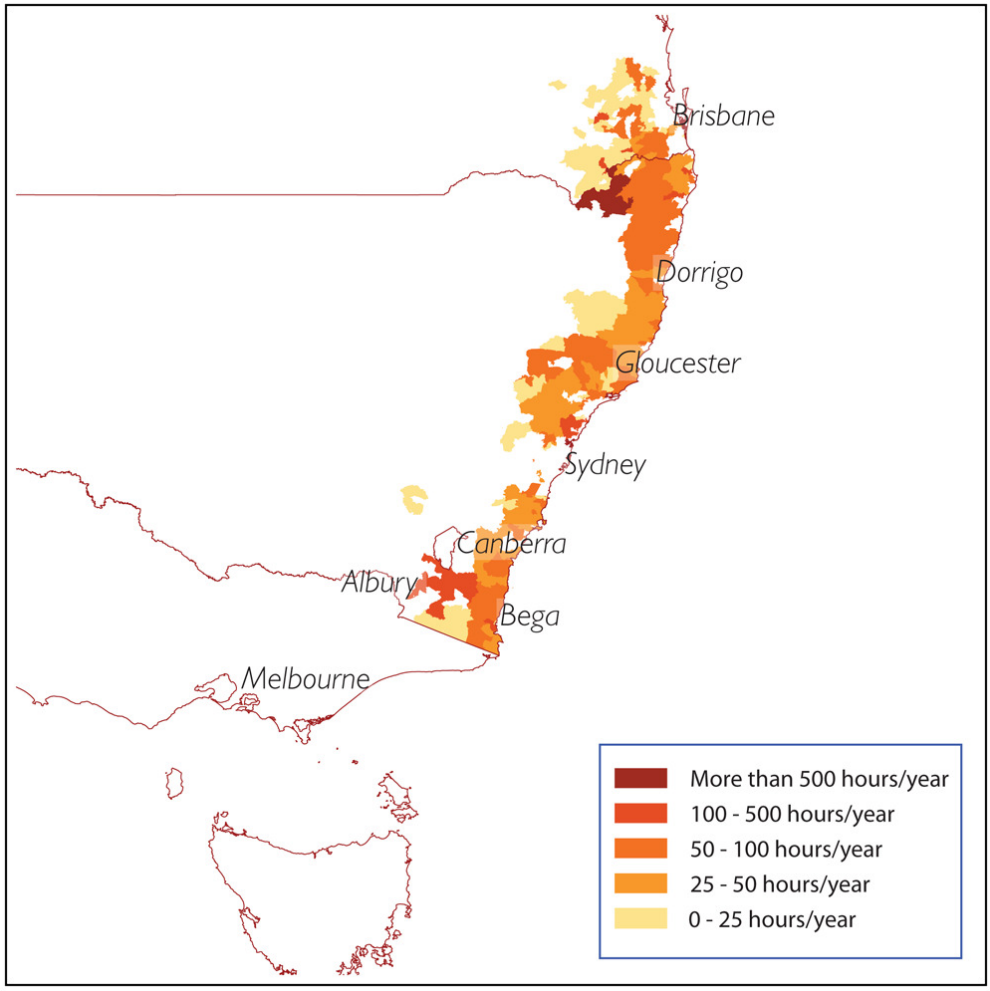

Figure 3.8: Time spent on fireweed control (hours/year) – mean score of those who attempt to control fireweed, by post code

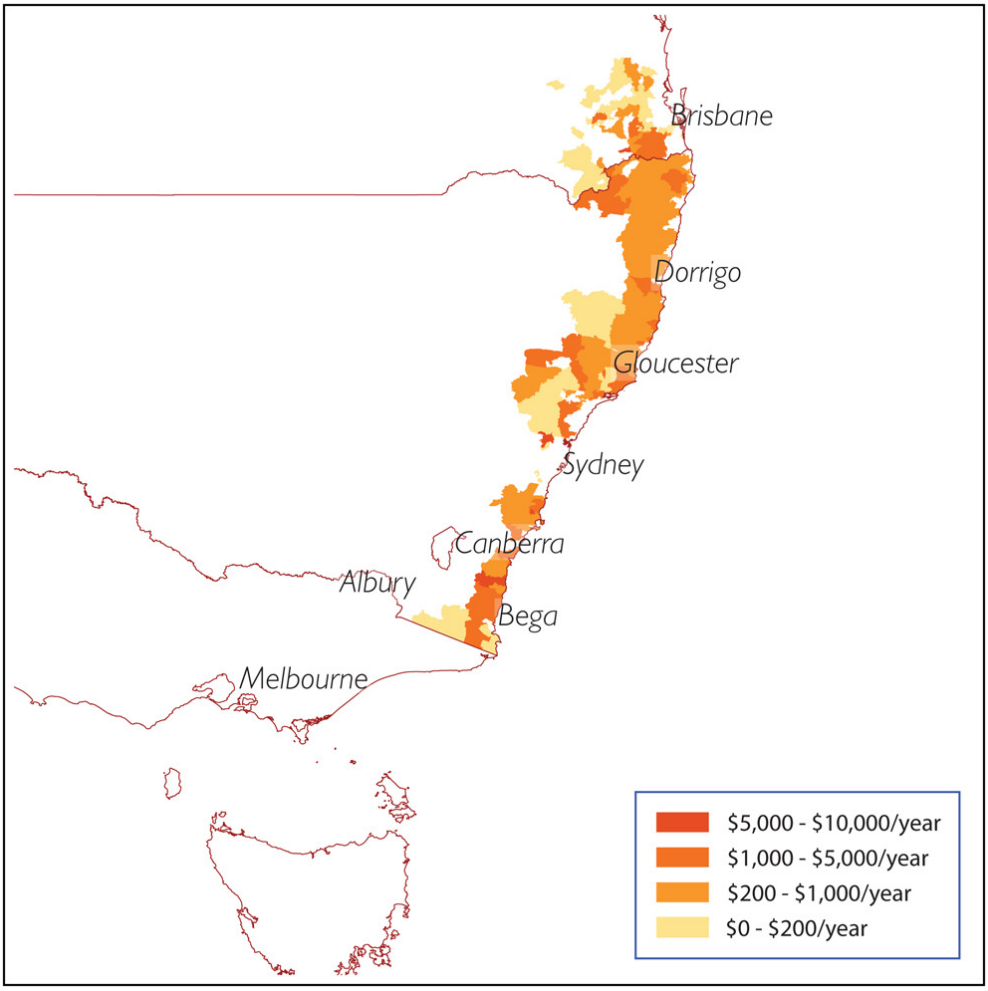

Figure 3.9: Money spent on fireweed control ($/year) – mean score of those who attempt to control fireweed, by post code

3.2.14. Noxious weed declaration/prohibition

Over 62 per cent of respondents considered that fireweed should be declared noxious or prohibited under legislation (Table 3.23; Figure 3.10). Only 18.8 per cent of respondents from the Lismore region were in favour of declaration or prohibition, and 29.4 per cent in the Gloucester region. However, relatively high proportions of respondents from Cumberland, Southern Inland NSW, Mid-North Coast and South-East Qld are in favour of having the weed declared noxious.

It is notable that, with the exception of Cumberland, many respondents from these regions have experienced fireweed invasion for a relatively short time period (Figure 3.3). Furthermore, there was a significant relationship between support for declaration or prohibition and duration of fireweed presence on farm. Those for whom fireweed had been present on their property for a longer period, were less supportive of the weed being prohibited or declared noxious. Similarly, those who had a large or moderate amount of fireweed on their property were less likely to support declaration or prohibition than those who had a small amount of the weed. However, those who considered fireweed to be

their worst weed were somewhat more likely to support declaration than those who did not.

The results suggest that those who have had fireweed for longer, or have a larger amount of the weed on their property, are finding it to be an intractable farm management issue. As a result, they do not want to face sanction for being unable to control the weed to a desired extent on their farm. In contrast, respondents who have faced fireweed incursion for a shorter time, or only have a small amount of the weed on farm, may believe declaration or prohibition of fireweed may help restrict its spread to its full theoretical extent in the region, and on their property.

Table 3.23: Whether fireweed should be declared noxious or prohibited, as a percentage of respondents with fireweed 2011

	Should fireweed be declared noxious or prohibited under legislation?		
Survey regions	**Yes**	**No**	***n***
Overall survey*	62.4	37.6	*723*
Cumberland	96.6	3.4	*29*
Hexham	53.7	46.3	*41*
Muswellbrook	50.0	50.0	*36*
Northern Tablelands/NW Slopes	63.6	36.4	*22*
Gloucester	29.4	70.6	*17*
Taree/Wauchope	48.5	51.5	*66*
Mid-North Coast	75.3	24.7	*77*
Lismore	18.8	81.2	*80*
Shoalhaven	84.1	15.9	*107*
Bega	63.4	36.6	*123*
Southern Inland NSW	88.9	11.1	*9*
South-East QLD	71.6	28.4	*116*

** Overall survey response includes those who did not provide a post code*

Respondents were asked to indicate why they thought fireweed should or should not be declared noxious or prohibited. For those who agreed with declaration or prohibition, the largest proportion believed that it was required to force neighbours to control the weed (Table 3.24). Respondents commented that fireweed on neighbouring properties made it difficult or impossible to control on their own land owing to the wind-borne spread. They believed that some neighbours did not care about fireweed or were not aware of its importance, and so enforcement was the only way to have these individuals begin to control the weed. Several respondents believed that lifestyle and absentee farmers and public land managers were particularly poor fireweed managers, and that enforcement was needed. As one commented, 'It will be impossible to eradicate fireweed as long as neighbours and councils leave it to grow without any intervention'.

A large proportion of those in favour of prohibition or declaration believed that it was necessary because of the potential and actual impacts of fireweed on their land (Table 3.24). Respondents were concerned about the ability of fireweed to 'take over' productive pastures, with one commenting that it was 'one of the

greatest threats to agriculture'. Concerns were also raised over its potential to poison livestock, the economic impact on farmers in the district, and the potential of fireweed to spread rapidly over a wide area.

Table 3.24: Why fireweed should be declared noxious or prohibited, as a percentage of respondents with fireweed who agreed with declaration or prohibition 2011 (multiple response)

Why fireweed should be declared noxious	***Percentage***
Force/encourage neighbours to control the weed	28.9
Fireweed causes problems for farmers (e.g. stock poisoning, impact on pasture, economic losses)	24.5
Limit spread in district/on my property	19.9
Force/encourage community action	14.3
Force/encourage local government/public land managers to control the weed	8.7
Encourage greater government spending/research on fireweed control	3.7

n = 322

Amongst those who were not in favour of declaration or prohibition of fireweed, the highest proportion suggested that it was counter-productive as the weed was too difficult to control adequately (Table 3.25). A common theme was that control techniques available for fireweed were inadequate, and so many farmers would inevitably be in breach of declaration. Some suggested that it was preferable to try to live with fireweed in a managed state, or that other weeds in their district were more important. Many respondents expressed futility about ever being able to control fireweed, with one stating:

> *I just don't know if fining people would help. It just spreads everywhere. I don't think it can be stopped.*

Likewise, a high proportion of those not in favour of declaration/prohibition believed fireweed was too expensive to control (Table 3.24). Many believed that farmers were already overburdened with costs, and a legal expectation to control fireweed might drive farmers off the land. As one commented:

> *If I were required to control of my fireweed, it would send me broke. I can only afford to attend to the worst portions of my farm each year.*

*Table 3.25: Why fireweed should **not** be declared noxious or prohibited, as a percentage of respondents with fireweed who disagreed with declaration or prohibition 2011 (multiple response)*

Why fireweed should not be declared noxious	Percentage
It is too difficult to control adequately	36.1
It is too expensive to control	28.4
Fireweed is not a significant enough problem	10.3
It is too late to enforce control	5.8
Enforcement would encourage too much herbicide use	5.2
Enforcement has not worked for fireweed and other weed species	4.8
There is already too much government regulation	4.2
It is only a seasonal problem	2.3
Farmers are already attempting to control fireweed	1.6
Prior enforcement has not worked for fireweed	1.3

n = 310

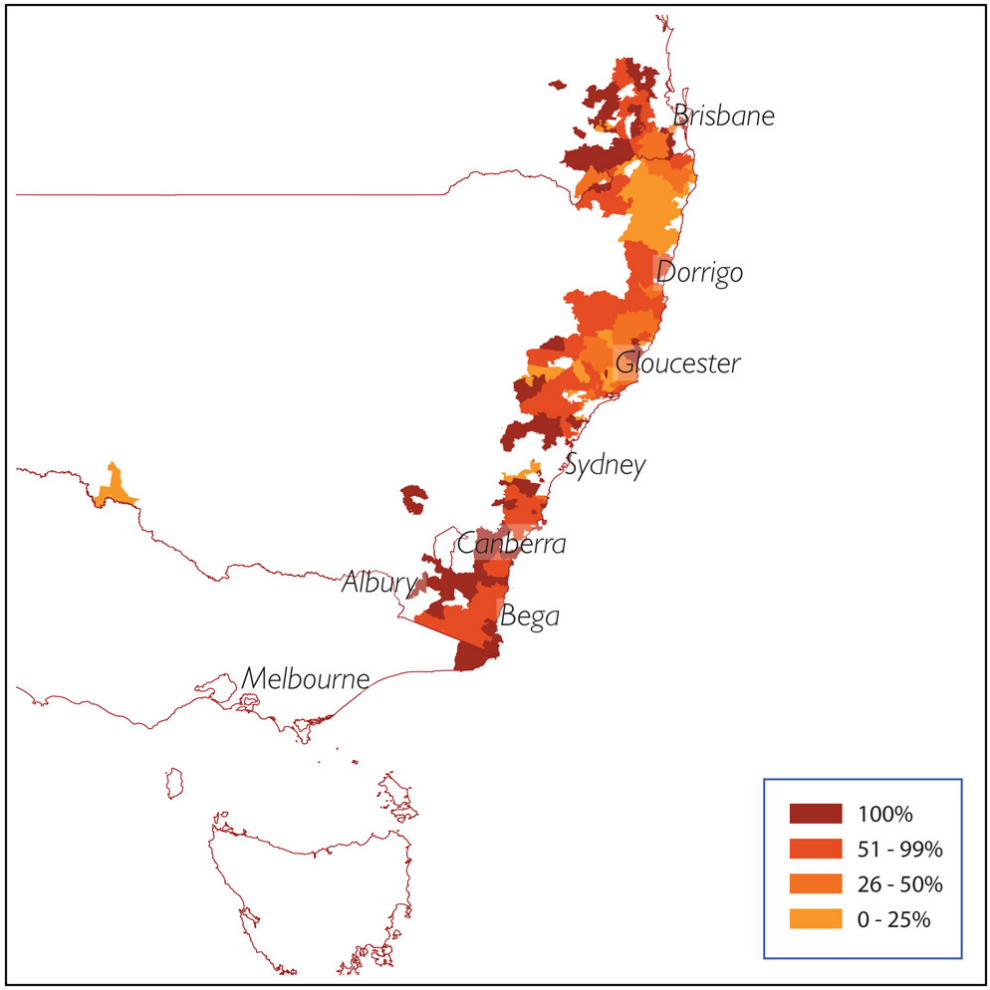

Figure 3.10: Proportion of respondents in favour of fireweed being declared noxious or prohibited, by post code

3.2.15. Future control of fireweed

Controlling fireweed on property in the next five years

Farmers appear to be relatively positive overall regarding the future control of fireweed using control methods that are currently available, with 60 per cent of respondents indicating that it will be possible to either eradicate fireweed from their property entirely, or restrict it to a small outbreak each year (Table 3.26). Respondents from Hexham, Gloucester, Bega, Lismore and Muswellbrook appear the most pessimistic overall regarding their future ability to control fireweed, with over 40 per cent believing fireweed will either remain a significant problem, or get worse. Respondents from Bega and Southern Inland NSW were most likely to consider that fireweed would become more of a problem on their property. Those from the Northern Tablelands/NW Slopes, Cumberland and Shoalhaven regions appear to be the most positive about their future capacity to control fireweed.

Farmers who had fireweed on their property for more than 30 years were the most pessimistic about their future ability to control the weed effectively, while those who had the weed for less than five years were most likely to consider themselves able to eliminate it entirely in the next five years. Farmers who did not consider fireweed a problem were the most likely to consider themselves able to eliminate it on their property, while those who considered it a major problem were the most likely to believe it would become more of a problem.

Those who had a small amount of fireweed, or had it under control, were significantly more likely to consider themselves able to eliminate the weed or restrict it to a small annual outbreak. Sheep and goat producers were likewise significantly more likely to consider themselves able to restrict or eliminate fireweed on their property than beef graziers or dairy farmers.

Table 3.26: Whether it will be possible to control fireweed in the next five years using current management techniques, as a percentage of respondents with fireweed 2011

	Will it be possible to control fireweed on your property effectively in the next five years using current management techniques?				
Survey regions	It will be possible to eliminate fireweed entirely	It will be possible to restrict fireweed to a small outbreak each year	Fireweed will remain a significant problem	Fireweed will become more of a problem	*n*
Overall survey*	8.1	51.7	27.1	13.1	*749*
Cumberland	10.3	62.1	20.7	6.9	*29*
Hexham	7.0	39.5	48.8	4.7	*43*
Muswellbrook	8.6	51.4	34.3	5.7	*35*
Northern Tablelands/NW Slopes	20.8	58.3	8.3	12.5	*24*
Gloucester	0.0	52.6	36.8	10.5	*19*
Taree/Wauchope	1.4	61.4	32.9	4.3	*70*
Mid-North Coast	7.5	53.8	31.2	7.5	*80*
Lismore	5.1	51.3	34.6	9.0	*78*
Shoalhaven	5.7	61.9	19.0	13.3	*105*
Bega	5.5	49.6	21.3	23.6	*127*
Southern Inland NSW	22.2	44.4	11.1	22.2	*9*
South-East QLD	16.5	40.5	23.1	19.8	*121*

** Overall survey response includes those who did not provide a post code*

The importance of an effective biological control agent for fireweed

Preliminary research into biological control agents for fireweed has been conducted in South Africa as part of this research project.

Survey respondents were asked to consider whether an effective biological control agent was important for fireweed control on their property (Table 3.27). Overall, 53.7 per cent considered it would be a 'very important' development, while only 18.1 per cent thought it was 'not important' (Table 3.27). Respondents from the Bega, Lismore, Southern Inland NSW and Cumberland regions were most likely to consider this a very important issue, suggesting that landholders in these regions are more likely to be searching for alternative fireweed control strategies because their existing approach is not working satisfactorily.

Those who had fireweed on their property for 10 years or more were significantly more likely to consider a biological agent very important than those who had the weed for less than 10 years. Similarly, those who had a large amount of fireweed on property were significantly more likely to consider biological control a very important issue, while those who had only small amounts of fireweed were the most likely to consider biological control unimportant (Table 3.28). Similarly, the proportion of respondents strongly in favour of effective biological control of fireweed was positively correlated with

the significance of the fireweed problem, with those considering fireweed to be a major problem significantly more likely to consider biological control very important.

Table 3.27: The importance of an effective biological control agent for fireweed control on property, as a percentage of respondents with fireweed 2011

	The importance of an effective biological control agent for fireweed control on property			
Survey regions	Not important	Somewhat important	Very important	n
Overall survey*	17.8	28.4	53.8	753
Cumberland	17.2	27.6	55.2	29
Hexham	17.4	37.0	45.7	46
Muswellbrook	27.8	33.3	38.9	36
Northern Tablelands/NW Slopes	36.0	24.0	40.0	25
Gloucester	20.0	35.0	45.0	20
Taree/Wauchope	14.3	40.0	45.7	70
Mid-North Coast	11.2	33.8	55.0	80
Lismore	10.8	30.1	59.0	83
Shoalhaven	18.3	26.9	54.8	104
Bega	18.5	16.1	65.3	124
Southern Inland NSW	11.1	33.3	55.6	9
South-East QLD	23.1	24.8	52.1	121

** Overall survey response includes those who did not provide a post code*

Table 3.28: Relationship between occurrence of fireweed and the importance of an effective biological control agent for fireweed control on property, as a percentage of responses

	Occurrence of fireweed			
The importance of an effective biological control agent for fireweed control on property	Small amounts	Moderate amounts	Large amounts	Under control
Not important	34.9	8.7	3.6	15.6
Somewhat important	32.9	31.1	10.9	29.2
Very important	32.2	60.2	85.5	55.2
n	255	289	110	96

chisq = 127.797, d.f. = 6, p = 0

Changing farm management to control fireweed more effectively

Respondents were asked to list any management changes they intended to make in the next two years to control fireweed more effectively on their property. Responses were coded for quantitative analysis (Table 3.29). The largest proportion of respondents indicated that they would not change their fireweed management approach. The majority of these did not provide details, although a few believed their current management approach allowed them to manage fireweed effectively. Some suggested that fireweed was 'not a major problem' on their land and so they did not need to change their approach. Others believed they were unable to do any more to control fireweed, for example due to cost or time restrictions.

A significant proportion of respondents suggested they might incorporate herbicide control, pasture improvement (as well as the related methods of rotational/cell grazing and reduced stocking rates), and grazing with sheep or goats into their fireweed management strategy over the next two years (Table 3.29). With the exception of hand weeding, these were found to be amongst the most effective fireweed control methods used by respondents (Table 3.19). Farmers who may perceive a growing fireweed threat on their land recognise these to be amongst the most effective methods for outbreaks of a scale that make hand weeding impractical. One respondent noted that they were 'seriously considering buying a wick wiper and using chemicals which we don't like doing as we prefer biological farming'.

Respondents also showed a willingness to trial different control methods to come up with an approach that worked well on their farm. As one commented, 'we are in the throes of moving from management by constant spot spraying and the grazing off of flower heads by goats, to broadacre spraying every two/three years, with some strategic mulching of fireweed incorporated into our pasture improvement program'. A high proportion also indicated they would adopt a number of the methods listed in Table 3.29 as part of an integrated approach.

Table 3.29: Fireweed management changes to be made in the next two years, as a percentage of coded responses (multiple response)

Fireweed management changes to be made in the next two years	***Percentage***
Change nothing	26.4
Pasture improvement	14.9
Herbicides	12.0
Grazing with sheep or goats	8.3
Slashing and mulching	6.8
Be vigilant and monitor/ control regularly	4.9
Already doing all that is possible	4.2
Pulling out by hand	3.7
Rotational/cell grazing	3.6
Reduced stocking rates	2.6
Control earlier in the season	2.3
Other control methods	1.9
Sub-contract control activity/employ casual staff/volunteers	1.8
Encourage neighbours to do more to control fireweed on their land	1.5
Would like to trial biological control	1.3
Grazing management	1.1
Systematic/targeted inspection and control	1.1
Cultivation	0.6
Work with neighbours/Landcare groups	0.5
Introduce quarantine measures	0.3
Give up controlling fireweed	0.2
Increase time spent controlling fireweed	0.2
Other	3.6

n = 640

3.2.16. Environmental, economic and social impacts

Environmental impacts of fireweed

Overall, respondents considered the environmental impact of fireweed to have been relatively minor, with the largest being 17.4 per cent of respondents considering the weed to have had an impact on conservation areas (Table 3.30). The impact on conservation areas was considered to have been somewhat higher amongst those from the Cumberland, Bega and Mid-North Coast regions. Only just under 12 per cent of respondents overall believed fireweed had an impact on native plants, and just under 4 per cent on native animals.

Other noted environmental impacts of fireweed included:

- reducing the quantity of native pasture species available to native animals;
- competing with threatened plant species, such as native *Asteraceae*;
- impact on National Parks; and
- secondary impacts, such as from the increased use of herbicides on farm.

Many respondents noted that they were not aware of any environmental impacts, while some speculated that the weed was rarely grazed by native animals such as kangaroos. Others noted that fireweed was primarily an agricultural not environmental weed.

Table 3.30: The environmental impacts of fireweed, as a percentage of respondents with fireweed 2011

	Environmental impacts of fireweed				
Survey regions	**Impact on native animals**	**Impact on native plants**	**Impact on conservation areas**	**Other impact**	***n***
Overall survey*	3.9	11.7	17.4	3.3	*788*
Cumberland	0.0	3.4	24.1	0.0	*29*
Hexham	0.0	17.4	17.4	4.3	*46*
Muswellbrook	5.6	16.7	13.9	0.0	*34*
Northern Tablelands/NW Slopes	0.0	0.0	19.2	3.8	*26*
Gloucester	0.0	15.0	5.0	10.0	*20*
Taree/Wauchope	0.0	8.6	11.4	2.9	*70*
Mid-North Coast	6.2	15.0	23.8	6.2	*75*
Lismore	2.4	12.2	11.0	0.0	*80*
Shoalhaven	3.7	10.3	23.4	4.7	*103*
Bega	7.0	16.3	24.0	4.7	*129*
Southern Inland NSW	0.0	0.0	12.5	0.0	*8*
South-East QLD	6.5	11.3	12.9	1.6	*124*

** Overall survey response includes those who did not provide a post code*

Economic and social impacts of fireweed

The most significant economic impacts of fireweed on farmers included lack of time available to devote to other activities, and overall farm profitability (Table 3.31). Fireweed control appeared to be particularly time consuming in the Shoalhaven, Bega and Mid-North Coast regions, and it is notable that these regions are amongst those where fireweed is considered a larger problem (Figure 3.4). A respondent stated that the weed 'is by far the most negative feature of our farm. Other jobs are continually put on hold while fireweed is treated.'

The impact of fireweed on farm profitability was greatest in the Lismore and Mid-North Coast regions, and was considered a less important issue in the Northern Tablelands/NW Slopes. One respondent indicated that farm profitability has suffered as a result of reducing stocking rates in an attempt to encourage greater pasture competition with fireweed.

Cross tabulation revealed that sheep producers are significantly less likely to be affected by lack of time or reduced farm profitability as a result of fireweed infestation than dairy and beef producers, suggesting that sheep grazing, which is likely to reduce the occurrence of fireweed, may have economic benefits for farmers. As one respondent noted 'it is not a problem on my place, my sheep control it'.

The eventual ability of the farmer to sell their farm at a reasonable price was considered to be impacted by fireweed by just under 12 per cent of respondents overall, however approximately 20 per cent from the Bega and Mid-North Coast regions felt this applied to their circumstances. Similarly, respondents from these regions were amongst the most likely to consider fireweed to have a negative impact on their property's market value.

It is notable than nearly 20 per cent of all survey respondents considered that fireweed impacted negatively on the health of their livestock, with this issue being of particular importance in South-East Qld, Lismore and Hexham. Although livestock death by fireweed poisoning is relatively unusual, it is considered to be relatively common that it will cause ill-thrift and poor growth in young cattle. Varying degrees of chronic, but not fatal, damage have been seen in animals from the central coast of New South Wales (Watson et al. 1984). Livestock will generally avoid grazing fireweed when sufficient alternative pasture is available. The risk posed to livestock by fireweed will therefore depend on the scale of the infestation on a property or paddock, and pasture coverage. One respondent wondered 'if fireweed is the cause of some calves not doing as well as others'.

Table 3.31: The economic impacts of fireweed, as a percentage of respondents with fireweed 2011

	Economic impacts of fireweed						
Survey regions	Livestock health	Farm profitability	Long-term farm viability	Market value of farm	Lack of time for other activities	Eventual ability to sell farm for reasonable price	*n*
Overall survey*	19.9	33.4	20.9	19.4	45.6	11.9	*788*
Cumberland	13.8	27.6	17.2	6.9	44.8	6.9	*29*
Hexham	26.1	34.8	15.2	13.0	37.0	6.5	*46*
Muswellbrook	19.4	33.3	16.7	25.0	30.6	11.1	*36*
Northern Tablelands/NW Slopes	23.1	15.4	23.1	26.9	26.9	15.4	*26*
Gloucester	20.0	30.0	15.0	10.0	20.0	0.0	*20*
Taree/ Wauchope	20.0	37.1	15.7	20.0	35.7	7.1	*70*
Mid-North Coast	22.5	43.8	32.5	23.8	56.2	18.8	*80*
Lismore	25.6	43.9	18.6	14.6	45.1	3.7	*82*
Shoalhaven	10.3	35.5	21.5	18.7	61.7	12.1	*107*
Bega	20.2	35.7	28.7	29.5	58.9	20.9	*129*
Southern Inland NSW	12.5	25.0	12.5	25.0	37.5	12.5	*8*
South-East QLD	26.6	26.6	18.5	16.9	41.1	12.9	*124*

** Overall survey response includes those who did not provide a post code*

Overall, the various social impacts of fireweed were noted by lower proportions of respondents than the economic impacts, however the most significant impact was tension with neighbours (26.4 per cent; Table 3.32). Tension with neighbours was noted throughout the survey, neighbours being regarded by some respondents as the source of fireweed infestation on their property, and being the reason that some have stopped controlling fireweed on their property (because neighbours do not 'do their bit'), while poor fireweed control by neighbours was considered the most important factor behind 'bad' fireweed years (Section 3.2.6). As one respondent indicated, 'when neighbours ignore [fireweed], good landowners pay the price.' Fireweed was more likely to cause tension with neighbours in Bega and Shoalhaven, where the weed has continued to spread, but was a less significant issue in the established fireweed regions of Gloucester, Lismore, Hexham and Muswellbrook.

The time consuming nature of fireweed control may also be considered a social impact, with one respondent suggesting that the 'time spent hand pulling is time that could be spent on improvements/family time. Our family hates fireweed!'

Social impacts were most notable in the Mid-North Coast and Bega, with respondents from these regions more likely to consider each of the issues important than respondents overall.

Just under 10 per cent of respondents overall noted personal physical health issues arising from fireweed, with nearly 24 per cent of respondents from the Mid-North Coast, and 20.2 per cent from Bega, identifying this issue. Respondents noted 'illness as a result of pulling without gloves'. Likewise, conflict with local government as well as emotional and mental health impacts appeared to he relatively high in Bega and the Mid-North Coast.

Table 3.32: The social impacts of fireweed, as a percentage of respondents with fireweed 2011

	Social impacts of fireweed					
Survey regions	Tension with neighbours	Conflict with local government/ weeds authority	Personal/ family physical health	Personal/ family emotional/ mental health	Farm succession plans within family	*n*
Overall survey*	26.4	12.8	9.8	11.5	3.6	*788*
Cumberland	31.0	17.2	0.0	10.3	6.9	*29*
Hexham	15.2	0.0	2.2	2.2	4.3	*46*
Muswellbrook	16.7	8.3	0.0	8.3	2.8	*36*
Northern Tablelands/NW Slopes	19.2	0.0	3.8	7.7	11.5	*26*
Gloucester	0.0	5.0	0.0	10.0	0.0	*20*
Taree/ Wauchope	22.9	4.3	5.7	4.3	1.4	*70*
Mid-North Coast	33.8	23.8	23.8	22.5	8.8	*80*
Lismore	12.2	3.7	1.2	3.7	0.0	*82*
Shoalhaven	41.1	17.8	11.2	13.1	0.0	*107*
Bega	41.1	22.5	20.2	25.6	4.7	*129*
Southern Inland NSW	37.5	25.0	0.0	0.0	0.0	*8*
South-East QLD	21.8	12.9	8.9	7.3	4.8	*124*

** Overall survey response includes those who did not provide a post code*

3.2.17. General comments from respondents

As in the 1985 survey, many respondents who made additional comments expressed concern about the growing threat posed to them or in their district by fireweed, as well as discussing the highly difficult task posed by fireweed at the time they were surveyed.

Some respondents commented that fireweed is not a significant problem on their property, because they only have a few plants which they easily manage each year, because the weed is not established in their district, or because they manage it effectively using sheep/goats or some other method or range of methods.

Many cited neighbours who do not control fireweed (particularly hobby farmers), as well as public land managers (council, National Parks etc) as significant in making it impossible to eradicate or in some cases manage fireweed on their land.

Reiterating findings from earlier in the survey, a large number of comments were received regarding the effectiveness of sheep/goats and pasture improvement in making fireweed manageable on many properties. This was at times contrasted with slashing, which it was said increased the ability of fireweed to set seed, and herbicide, which it was said created bare ground for easy reinfestation.

Other suggestions for improving the management of fireweed included:

- identifying and registering new selective herbicides with shorter withholding periods to make herbicide application more feasible on grazing or dairy properties;
- enforcing fireweed control to make those in the district not currently controlling the weed improve their efforts;
- educating the community on the impacts of fireweed and the best methods available to control it;
- improving efforts to control fireweed on public land, on which a number of respondents suspected little or no fireweed control was undertaken; and
- promoting the benefits of sheep and goat grazing.

Of significant concern to respondents was the need to introduce an effective biological control for fireweed, even if it meant sacrificing native *Senecio* species (though some respondents were concerned about the potential negative environmental impacts of biological agent release). Several respondents suggested there may already be biological agents controlling or restricting fireweed with some effectiveness, including rust, mites and other insects. Some farmers offered to conduct fireweed control trials on their property if required.

3.3. Conclusions and Recommendations

Fireweed remains a considerable concern for landholders along the south-eastern Australian coast and hinterland. It is highly invasive, and has had a significant economic and social impact in affected regions.

3.3.1. Occurrence and spread

Fireweed has continued to spread into new regions. It appears to be a relatively recent arrival in the NSW Northern and Southern Tablelands, parts of the NSW Mid-North Coast, and South-East Qld. Severe fireweed infestations have become more common in Bega, Shoalhaven, Lismore, NSW Mid-North Coast and South-East Qld. It has been present for longer in parts of the NSW far north coast, around Port Macquarie and Wauchope, the Gloucester/Taree region, the lower Hunter Valley, and the south-west fringe of Sydney. Many respondents indicated concern over the growing threat posed in their region by fireweed, although others commented that fireweed was not a significant problem on their property, or was under control.

Wind-blown seed was considered by survey respondents to be the most significant means of fireweed spread, followed by birds and other animals, and vehicles and machinery contaminated with seed.

Recommendation

Further research is needed to understand vectors of spread for fireweed, particularly dispersal via birds and wind-borne seed. The potential for birds to spread fireweed is currently unknown.

Fireweed was less likely to be considered a major problem in areas where it has only spread most recently, or in areas where it had occurred for the longest. It may be that respondents from the former were not yet fully impacted by fireweed, and those from the latter had over time learnt to live with/manage the weed more effectively. Similarly, those who had the weed on property for less time were significantly more likely to consider fireweed either no problem or a minor problem. In contrast, those who had a longer term fireweed infestation were more likely to consider it a moderate or major problem. It is notable, however, that those who had fireweed on their property for more than 30 years were relatively ambivalent about the size of the fireweed problem, with a similar proportion considering it a minor, moderate and major problem alike.

The factors considered most likely to contribute to bad fireweed years include poor fireweed control by neighbours, lack of time/labour/money to control fireweed effectively, and rainfall following drought.

Recommendation

Further research is needed to more specifically identify the particular climatic factors that contribute to 'bad' fireweed years.

Fireweed was the worst weed for about a third of respondents, and was more likely to be considered the worst weed in Bega, Shoalhaven, Hexham and the Mid-North Coast, and least likely in Muswellbrook and Gloucester. Other significant weeds in the fireweed-effected region included lantana, blackberry, and giant Parramatta grass. Miscellaneous thistles, broadleaf weeds, and grasses and sedges were also highly ranked.

Bare ground and heavily grazed pasture appear to be the most significant situations favouring the growth of fireweed, though given the significant proportion of respondents who nominated 'no particular situation', it is clear there is a perception that fireweed is capable of growing at problematic levels regardless of the soil/pasture circumstances – a number of survey respondents stated that the weed 'grows everywhere'.

Both dairy and beef producers were significantly more likely to have large or moderate fireweed infestations on their property than sheep producers, and similarly were more likely to perceive fireweed as a moderate or major problem, reflecting perhaps the ability of sheep to control fireweed to an extent and the location of sheep properties further away from the coast where fireweed is most dominant. Fireweed also appeared more likely to compete with crops and pasture on dairy and beef properties. Improved and heavily grazed pasture, and bare ground, were more likely to favour fireweed growth on beef properties than either dairy or sheep properties.

3.3.2. Control methods

As was also found in 1985, over 80 per cent of respondents attempted to control fireweed using one or more methods. Approximately 12 per cent had given up controlling the weed. Common reasons for no longer controlling fireweed included that it was a losing battle, that control had proven ineffective, that it took too much out of farm finances, and that there was no point when neighbours were doing little or nothing to manage the weed on their property.

The survey indicated that considerable success with fireweed control can be achieved through an integrated approach that may incorporate encouraging strong competitive pastures, hand weeding, herbicide control, and grazing with sheep or goats. The combination of methods used will depend on their viability in different circumstances.

Since 1985, fireweed management practices have changed. Slashing and cultivation are less likely to be used, while the use of herbicides and grazing with sheep or goats appears to have increased, though the latter result may in part be due to the inclusion of non-beef and dairy landholders in the more recent survey.

Of the fireweed control methods available, hand weeding remained the most common and one of the most effective control methods according to respondents, though it was very time-consuming, labour-intensive and physically demanding. Hand weeding appears to be favoured for targeted management of fireweed on particular parts of the property, or for smaller

outbreaks. Respondents from regions which had experienced less pressure from fireweed incursion were more likely to favour removing the plants by hand.

Slashing and cultivation had declined in popularity since 1985, though slashing remained a relatively popular method with 36 per cent of respondents still controlling fireweed using this technique. Despite its ongoing relative popularity, slashing was considered to have a number of potential drawbacks, with many respondents suggesting it makes the problem worse, presumably because of the spread of seed. However others stated that if carried out correctly, it can have some success (involving regular follow up slashing to avoid flowering and seeding of fireweed plants).

The proportion of farmers controlling fireweed with herbicide appeared to have increased significantly, particularly in the Cumberland, Mid-North Coast, South-East Qld, and Shoalhaven regions. However, some survey respondents suggested that herbicide created ongoing fireweed control problems, as it created bare ground on which fireweed reinfestation could easily occur. Others commented that identifying and registering new selective herbicides with shorter withholding periods was an important future priority, to make herbicide application more feasible on grazing or dairy properties. Such comments may have been made due to recent restrictions being placed on the use of the selective and most effective herbicide bromoxynil.

While promoting competitive pasture is a longer term control method for fireweed, it appears that the use of this method had not increased since the first survey was conducted in 1985. Greater uptake of this method should give farmers ongoing fireweed control benefits, particularly as it was noted in this survey that overgrazing and bare ground favour fireweed establishment and contribute significantly to 'bad' fireweed years. Overall, kikuyu was considered to be the best species for fireweed control, followed by ryegrass, paspalum, and white clover. Where pasture improvement was used successfully by respondents to reduce the intensity of fireweed, healthy pastures were encouraged through application of fertiliser and lime, promotion of native and introduced pasture species, and reduced grazing pressure or grazing rotation strategies.

Grazing with sheep or goats was considered to be the most successful fireweed control method overall. However, just over 10 per cent of respondents used sheep or goats to graze fireweed on their property. Furthermore, the data indicated that the proportion of beef graziers and dairy farmers using this method may only have increased marginally since 1985. However, a number of survey respondents mentioned that they would like to introduce sheep or goats onto their property in the next few seasons to improve fireweed control. Sheep or goat producers spent significantly less time and money on fireweed control, and sheep producers were less likely to consider fireweed to have an impact on farm profitability. Importantly, however, establishing sheep or goats on a cattle property can impose a large cost on farmers in terms of farm infrastructure.

Nonetheless, a variety of comments were received regarding the effectiveness of grazing with sheep or goats, and pasture improvement, in making fireweed manageable on many properties. Several comments were received stating that

the benefits of sheep and goat grazing for fireweed control needed to be promoted amongst rural landholders.

Those who had success reducing the extent of fireweed on their property were most likely to credit their success to one, or a mixture, of hand weeding, pasture competition, and herbicide application. Often these and other approaches were successfully used together as part of an integrated strategy.

Recommendation

Extension is required to ensure farmers are aware of correct herbicide use for fireweed control. Correct herbicide application should not created bare ground to the extent that a number of survey respondents identified. The NSW DPI has conducted successful herbicide trials, and so the results of this research need to be extended to farmers, and tailored to different geographic regions.

Landholders also need to be made aware of other successful methods to manage fireweed on their land. Pasture improvement and grazing with sheep or goats were considered by respondents to be relatively successful control methods. Hand weeding was also popular, particularly for smaller infestations. There is potential to increase the number of landholders using these methods as part of an integrated strategy through education.

Of particular importance will be extending best practice control to those landholders who currently show little interest in controlling fireweed. Extension must highlight the need for vigilance and long-term dedication in monitoring and management of fireweed, as a significant proportion of respondents suggested these were important elements behind their successful reduction of the weed.

3.3.3. Cost of control

Nearly half of respondents estimated that they spent over 50 hours each year controlling fireweed on their property, while nearly 40 per cent estimated they spent $1,000 or more on control activity. Fireweed control appeared to be more time consuming and expensive for residents in Hexham, Bega, Shoalhaven and the Mid-North Coast. Of those who consider fireweed to be under control on their property, approximately 50 per cent spend more than 50 hours and more than $1,000 per year on control activity. This suggests that maintaining fireweed at a controllable level on farm can be a significant ongoing cost to farmers in time and money.

Recommendation

A case study approach may be useful in quantifying the cost of fireweed control activities on farm. Options include exploring the cost for different types of production (for example, dairy, beef and sheep), different regions, and on farms which experience low and high levels of infestation respectively. It may also be helpful to quantify the cost of different weed control methods (such as herbicide and sheep/goat grazing) to help farmers decide on the relative merits of different methods.

3.3.4. Enforcement

Over 62 per cent of respondents believe fireweed should be declared noxious or prohibited under legislation. Those who had fireweed on their farm for longer, or who had larger infestations, often find it an intractable farm management issue. They appeared less likely to support declaration or prohibition, given they were unable to control the weed to a desired extent on their farm. In contrast, respondents who had faced fireweed incursion for a shorter time, or only had a small amount of the weed on farm, were more likely to support declaration or prohibition of fireweed. They may believe declaration or prohibition could help restrict fireweed spread to its full theoretical extent in the region, and on their property.

Several respondents commented that enforcing fireweed control was important to force those in the district not currently controlling the weed to improve their efforts. Others believed that managers had to be forced to control the weed more effectively on public land.

For those who agreed with declaration or prohibition, the largest proportions considered that it was required to force neighbours to control the weed, and that enforcement was a necessary part of the overall strategy to deal with the significant threat fireweed posed to agricultural production. Those not in favour of declaration or prohibition, however, were likely to consider it counter-productive, as the weed was seen as too difficult to manage. Similarly, it was viewed as imposing an impossible legal obligation on many farmers.

Recommendation

Noxious weed regulation may need to be strengthened as part of an overall approach to restricting fireweed spread. However the surveys suggested that the focus should be on regions where fireweed is a more recent arrival and has a greater prospect of being managed, rather than in regions where the weed is an intractable problem for many farmers. In the latter circumstance, regulation may place an overwhelming burden on many farmers.

3.3.5. Future control of fireweed

Farmers appeared to be relatively positive overall regarding the future control of fireweed using currently available control methods. However, those from some regions (for example, Hexham, Gloucester, Bega, Lismore and Muswellbrook) were most pessimistic regarding their ability to control fireweed, as were those who have had the weed on their property for more than 30 years. Despite the relatively positive outlook for controlling fireweed using current methods, 53.7 per cent of respondents considered that a biological control option would be a 'very important' development in the fight against fireweed. Those who were most likely to support the deployment of a successful biological control agent included those who had fireweed on their property for longer, and those who had larger infestations. Several respondents commented on the vital importance of developing an effective biological control for fireweed to help reduce the impact in their region, or on their property.

Recommendation

There is a strong interest and demand for ongoing research into potential biological control options amongst farmers impacted by fireweed. A high priority for research funding for fireweed as a WoNS should be to continue the biological control research in South Africa that commenced as part of this project.

The largest proportion of respondents indicated that they were unlikely to change their fireweed management approach in the next two years. Of those that were contemplating change, many considered implementing herbicide control, pasture improvement and sheep or goat grazing, which were also found to be amongst the most successful fireweed control methods. Many farmers showed a willingness to trial different methods, either individually or as an integrated approach.

3.3.6. Environmental, economic and social impacts

Respondents overall considered the environmental impact of fireweed to be relatively minor, in line with its status primarily as an agricultural rather than environmental weed.

The most significant economic impacts of fireweed on farmers included lack of time available to devote to other activities, and overall farm profitability. Fireweed control appeared to be particularly time consuming in the Shoalhaven, Bega and Mid-North Coast regions, and it was notable that these regions were amongst those where fireweed was considered by a higher proportion of survey respondents to be a moderate or major problem. A respondent stated that the weed 'is by far the most negative feature of our farm. Other jobs are continually put on hold while fireweed is treated.' The impact of fireweed on farm profitability was considered greatest in the Lismore, Mid-North Coast and Taree/Wauchope regions. Nearly 20 per cent of all survey respondents considered that fireweed impacted negatively on the health of their livestock.

Recommendation

More detailed information is required to quantify the economic impact of fireweed on agricultural production, including identifying the practical level of tolerance farmers can assume for fireweed, benefit/cost analyses of its impact on pasture production, economic impact on a national scale, and impact on individual farmer livelihoods.

Fireweed does appear to contribute to a number of social problems in affected communities. Amongst the most important of these was tension between neighbours, which appeared particularly relevant in the Bega and Shoalhaven regions. Tension can arise due to neighbours who control fireweed poorly being considered a source of weeds by farmers who believed they were managing the weed well. Poor fireweed control by neighbours was considered the most important factor behind 'bad' fireweed years. Nearly 24 per cent of respondents from the Mid-North Coast identified personal physical health issues as a result of fireweed. Physical health impacts included physical exhaustion from the scale of the effort required, and illness arising from hand pulling without gloves (the

latter issue is being investigated through international collaboration between the University of New England and researchers in the USA, although there is no scientific evidence currently supporting it). Mental health issues were also considered important. Social impacts overall appeared to be of particular relevance in Bega and the Mid-North Coast.

Recommendation

Further research is also warranted regarding the social impacts of fireweed. Topics to explore include the strain fireweed imposes on farming families, conflict created between neighbours, and impacts on farmer health.

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Attachment 1: survey questionnaire

Attachment 2: fireweed best practice management guide