# 7 Challenges to adoption of weed management strategies

The development and understanding of best weed management practices is of little value if they are not adopted by producers. It is therefore essential to understand the challenges that landholders might face in endeavouring to adopt weed management strategies. Moreover, the ability of producers to discuss the challenges and possible negative consequences of the adoption of innovations is known to be an important factor in their adoption (Nicholson *et al.* 2003). An initial examination of the literature also indicated that there was relatively little information available on the adoption of weed management strategies by graziers (Dowling *et al.* 2000). It was therefore decided, that a part of this project would need to be dedicated to filling this gap. Consequently, these results on adoption are presented along side best management practice recommendations, as a guide to the types of problems that producers may encounter should they consider adoption of new practices. In terms of innovation transfer it is hoped that this frank presentation of the "worst" features of these "best" practices might encourage adoption.

# 7.1 RESULTS

## POSTAL SURVEY

### *PRODUCER AWARENESS AND ADOPTION OF SPRAY GRAZING*

A large proportion (87.9%) of respondents to the postal survey were aware of spray grazing (Table 7.1). In addition, a large proportion had trialled or used spray grazing and intended to continue using it in the future. Following the model of the adoption process presented in Figure 2.4, those respondents that were aware but had not trialled spray grazing were labelled "non-adopters". Regardless of their perceived success, those respondents that were aware and intended to continue using spray grazing were labelled "adopters". Those respondents (again

regardless of perceived success) who reported a "no" response in their intention to use spray grazing in the future were considered "dis-adopters".

**Table 7.1 The percentage of responses to questions about spray grazing**

| | Yes | No | Unsure | No response | n |
|---|---|---|---|---|---|
| Were you aware of spray grazing (all respondents) | 87.9 | 9.7 | 0.0 | 2.4 | 934 |
| Have you ever trialled or used spray grazing (of those aware of SG) | 63.9 | 34.5 | 0.0 | 1.6 | 821 |
| Did you find spray grazing successful? (of those that use SG) | 88.6 | 7.6 | 0.0 | 3.8 | 525 |
| Will you use spray grazing again? (of those reporting SG successful) | 90.3 | 3.2 | 0.9 | 5.6 | 465 |
| Will you use spray grazing again? (of those reporting SG unsuccessful) | 47.5 | 40.0 | 5.0 | 7.5 | 40 |

***REASONS FOR NON-ADOPTION OF SPRAY GRAZING***

The most commonly reported reason for non adoption was chemical aversion (Table 7.2). Respondents reporting this reason gave responses such as "prefer to be organic", "not keen on using so many chemicals", "keep chemicals to a minimum" and "aiming for chemical free". Other respondents gave more detailed responses including the reason for their aversion to chemicals such as "I wish to avoid sprays as much as possible as I believe they are a health hazard" and "I try to avoid chemicals wherever possible, too many cancers in our district". The code "do not use chemicals", indicated that the respondent was a formal (registered) or an informal organic producer.

The responses within the codes "no weeds suitable" and "not necessary" were very similar however an attempt was made to distinguish between those respondents reporting that they had no weeds suitable for spray grazing (e.g. "a lack of broadleaf pasture weeds") and those reporting that although the weeds were present they were not attempting to control them (e.g. "weed infestation not severe enough to warrant entire paddock sprayed and grazed"). In

coding these responses it was sometimes difficult to make this distinction and so the results may not be entirely accurate.

"Land not suitable" was most commonly reported as an issue with steep or rugged terrain. Examples of these response include "topography not suited, helicopter too expensive, too rough for boom spray" and "too difficult to traverse, too many rocks, low percentage of areas can be done economically". Responses falling into this category frequently made reference to the cost of aerial application as being prohibitive.

Expense was a commonly reported reason for non adoption both in terms of expected returns for financial outlays and the availability of funds.

The code of "alternative methods better" was used to describe responses indicating that other methods were employed in preference to spray grazing. The most commonly reported alternative method was the application of a lethal dose of herbicide (e.g. "spray to kill", "I prefer to use a selective herbicide"). Some responses under this code were more preventative such as "the cause of our weeds in bare ground. The effect is weed infestation. Spend our energy minimising/eradicating bare ground".

A large proportion of respondents (28.3%) did not provide any response to this question. Whilst there may be some respondents who failed to complete the question correctly there may be a proportion of graziers that have no reason for having not applied spray grazing. Despite being aware of it, they may simply have not considered it as an option. In this case deeper questioning would be required to reveal the real reason for non-adoption.

**Table 7.2 Respondent perceptions of the reasons they have not trialled or used spray grazing**

| Descriptive code | Inferential code(s) | %[A] |
|---|---|---|
| Chemical aversion | Beliefs and objectives | 10.6 |
| Not necessary | Unidentified | 10.6 |
| No weeds suitable | Unidentified | 8.5 |
| Land not suitable | Fixed environmental features | 7.4 |
| Expense | Profitability and expense | 6.4 |
| Alternative methods better | Relative advantage | 5.3 |
| Do not use chemicals | Beliefs and objectives | 4.2 |
| Do not have equipment | Resources and infrastructure | 3.5 |
| Lack of time | Operational priorities | 3.5 |
| Incompatible with farm operations | Resources and infrastructure | 2.8 |
| Paddocks not set up for it | Resources and infrastructure | 2.8 |
| Seasonal climatic conditions | Climatic variability | 2.1 |
| Do not know how | Availability of information | 1.8 |
| Herbicide resistance concerns | Herbicide resistance | 1.8 |
| Don't have required livestock | Resources and infrastructure | 1.4 |
| Chemical residue in livestock | Intersystem impacts | 1.4 |
| Livestock withholding periods | Intersystem impacts | 1.1 |
| No reason | Unidentified | 1.1 |
| Fencing failed | Resources and infrastructure | 0.4 |
| Livestock health issues | Intersystem impacts | 0.4 |
| Non target species damaged | Intersystem impacts | 0.4 |
| Only a short term fix | Relative advantage | 0.4 |
| Other weed priorities | Operational priorities | 0.4 |
| Social or family reasons | Family and lifestyle | 0.4 |
| Weeds are beneficial | Perceptions of weediness | 0.4 |
| No response given | | 28.3 |

[A] Expressed as a percentage of 283 respondents

***PROBLEMS WITH SPRAY GRAZING***

"Attaining the necessary stocking rate" was the most common problem that respondents had encountered whilst implementing spray grazing (Table 7.3). However, it was frequently reported from the angle of paddock size being the limiting factor, for example, "only works on small paddocks where a high stocking rate can be achieved" and "concentrating enough stock in large paddocks to eat scattered weeds". It was also reported as an issue with the availability of suitable stock at the necessary time, for example, "lack of numbers at the required time".

"Difficulties in timing of application" was frequently reported with reference to the weeds being too mature (e.g. "timing before weeds went to head") (Table 7.3).

Amongst those respondents reporting that they would not use spray grazing again "non target species damage" was the most common problem. They said such things as "it really stuffed the clover and grasses by the time the targets were knocked out", "loss of useful species" and "slow regeneration or medics and rye" were common. These respondents all focussed on damage to pasture species. In contrast, as well as reporting these impacts on pasture, a small proportion of those respondents who reported an intention to use spray grazing again also suggested non target species damage on trees and vineyards (e.g. "severe damage to kurrajong trees", "close proximity to vineyards").

Several respondents reported "climatic conditions at application" as a problem. Responses covered by this code included "rain soon after spraying", "frost stress", "cold weather leading to slow growth of weed" and "extreme temperatures after application".

**Table 7.3 Problems encountered by respondents reporting success with spray grazing and their intention to use again.**

| Problems | | Intention to use spray grazing again (%)[1] | | | | |
|---|---|---|---|---|---|---|
| | | Yes | No | Unsure | No response | Total |
| Descriptive code | Inferential code | n=420 | n=15 | n=4 | n=26 | n=465 |
| Attaining the necessary stocking rate | Resources and infrastructure | 18.8 | 6.7 | 0.0 | 11.5 | 17.8 |
| Difficulties in timing of application | Weed ecological influences | 10.5 | 0.0 | 25.0 | 3.8 | 9.9 |
| Non target species damaged | Intersystem impacts | 5.7 | 26.7 | 25.0 | 11.5 | 6.9 |
| Climatic conditions at application | Climatic variability | 5.7 | 0.0 | 0.0 | 3.8 | 5.4 |
| Getting chemical rates correct | Intellectual demand/learning process | 4.5 | 0.0 | 0.0 | 0.0 | 4.1 |

| Problems | | Intention to use spray grazing again (%)[1] | | | | |
|---|---|---|---|---|---|---|
| | | Yes | No | Unsure | No response | Total |
| Descriptive code | Inferential code | n=420 | n=15 | n=4 | n=26 | n=465 |
| Incomplete kill of weed | Unidentified | 3.3 | 13.3 | 0.0 | 3.8 | 3.7 |
| Seasonal climatic conditions | Climatic variability | 2.9 | 0.0 | 0.0 | 0.0 | 2.6 |
| Incompatibility with other farm operations | Intersystem impacts | 1.7 | 6.7 | 0.0 | 3.8 | 1.9 |
| Reduced livestock performance | Intersystem impacts | 1.2 | 0.0 | 0.0 | 7.7 | 1.5 |
| Poisoning of livestock | Intersystem impacts | 1.7 | 0.0 | 0.0 | 0.0 | 1.5 |
| Having time to do it | Operational priorities | 1.4 | 0.0 | 0.0 | 0.0 | 1.3 |
| Application in difficult terrain | Fixed environmental features | 1.2 | 0.0 | 0.0 | 3.8 | 1.3 |
| Overgrazing | Intersystem impacts | 1.4 | 0.0 | 0.0 | 0.0 | 1.3 |
| Paddock size | Resources and infrastructure | 1.4 | 0.0 | 0.0 | 0.0 | 1.3 |
| Expense | Profitability and expense | 1.0 | 6.7 | 0.0 | 0.0 | 1.1 |
| Loss of grazing when paddock closed | Intersystem impacts | 1.2 | 0.0 | 0.0 | 0.0 | 1.1 |
| Short term fix only | Relative advantage | 0.7 | 0.0 | 0.0 | 3.8 | 0.9 |
| Type of livestock | Resources and infrastructure | 0.7 | 6.7 | 0.0 | 0.0 | 0.9 |
| Withholding periods for livestock | Intersystem impacts | 0.7 | 0.0 | 0.0 | 3.8 | 0.9 |
| Don't like chemicals | Beliefs and objectives | 0.5 | 6.7 | 0.0 | 0.0 | 0.6 |
| New weeds emerged | Intra-system impacts | 0.5 | 0.0 | 25.0 | 0.0 | 0.6 |
| Contractor availability | External infrastructure | 0.5 | 0.0 | 0.0 | 0.0 | 0.4 |
| Herbicide resistance concerns | Herbicide resistance | 0.2 | 6.7 | 0.0 | 0.0 | 0.4 |
| Alternative methods better | Relative advantage | 0.0 | 0.0 | 25.0 | 0.0 | 0.2 |
| Effect not immediate | Observability | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 |
| Mistakes in application | Learning process | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 |

[1] Percentages represent the proportion of respondents within each group of respondents defined by intended future use of spray grazing. For example, 18.8% of respondents intending to use spray grazing in the future reported "attaining the necessary stocking rate" as a problem. Respondents did not have to provide a response and could also provide more than one reason and thus columns do not sum to 100%.

### *REASONS FOR FAILURE OF SPRAY GRAZING*

The coded reasons for spray grazing being unsuccessful are shown in Table 7.4. The most commonly reported reason for failure was an "inadequate stocking rate". This was frequently reported as "not stocking heavily enough". Incorrect timing of application was most commonly reported as too late application of chemical (e.g. "weeds too advanced when sprayed"). Perceived failure due to "climatic conditions at application" were most commonly reported as rainfall after application. The availability of a suitable "type of livestock" was a perceived reason for failure for some producers. This was commonly reported as an inadequate availability of suitable stock and so might be considered linked to stocking rate. One respondent reported failure with cattle. "Weed maturity differences" related to the staggered germinations of some targeted weeds. Producers reported this as a failure indicating that they were unable to control all weeds in one season.

**Table 7.4 The perceived reasons why spray grazing had failed and the intention of respondents as to its future use.**

| Problems | | Intention to use spray grazing again (%)[1] | | | | |
|---|---|---|---|---|---|---|
| | | Yes n=19 | No n=16 | Unsure n=2 | No response n=3 | Total n=40 |
| Descriptive code | Inferential code | | | | | |
| Inadequate stocking rate | Resources and infrastructure | 26.3 | 31.3 | 0.0 | 66.7 | 30.0 |
| Incorrect timing of application | Weed influences | 15.8 | 6.3 | 0.0 | 33.3 | 12.5 |
| Climatic conditions at application | Climatic variability | 15.8 | 0.0 | 0.0 | 0.0 | 7.5 |

| Problems | | Intention to use spray grazing again (%)[1] | | | | |
|---|---|---|---|---|---|---|
| | | Yes n=19 | No n=16 | Unsure n=2 | No response n=3 | Total n=40 |
| Descriptive code | Inferential code | | | | | |
| Incorrect rates applied | Intellectual outlay/learning process | 5.3 | 6.3 | 0.0 | 33.3 | 7.5 |
| Type of livestock | Resources and infrastructure | 10.5 | 6.3 | 0.0 | 0.0 | 7.5 |
| Weed maturity differences | Weed ecological influences | 5.3 | 6.3 | 50.0 | 0.0 | 7.5 |
| Paddock size | Resources and infrastructure | 10.5 | 0.0 | 0.0 | 0.0 | 5.0 |
| Short term fix only | Relative advantage | 0.0 | 12.5 | 0.0 | 0.0 | 5.0 |
| Stock not eating weed | Unidentified | 5.3 | 6.3 | 0.0 | 0.0 | 5.0 |
| Don't know or unsure | Unidentified | 0.0 | 6.3 | 0.0 | 0.0 | 2.5 |
| Don't like chemicals | Beliefs and objectives | 0.0 | 0.0 | 50.0 | 0.0 | 2.5 |
| General error in application | Unidentified | 5.3 | 0.0 | 0.0 | 0.0 | 2.5 |
| Incompatibility with other farm operations | Resources and infrastructure | 0.0 | 6.3 | 0.0 | 0.0 | 2.5 |
| Livestock performance compromised | Intersystem impacts | 5.3 | 0.0 | 0.0 | 0.0 | 2.5 |
| Non target species damaged | Intersystem impacts | 5.3 | 0.0 | 0.0 | 0.0 | 2.5 |
| Seasonal climatic conditions | Climatic variability | 0.0 | 0.0 | 0.0 | 33.3 | 2.5 |

[1] Percentages represent the proportion of respondents within the each group of respondents defined by intended future use of spray grazing. For example, 26.3% of respondents intending to use spray grazing in the future reported "inadequate stocking rate" as a problem. Respondents did not have to provide a response and could also provide more than one reason and thus columns do not sum to 100%.

## PRODUCER FOCUS GROUPS

The adverse features or limitations of individual weed management strategies for blackberry (*Rubus fruticosus*) and serrated tussock (*Nassella trichotoma*) derived from the focus groups

are presented in Table 7.5 and Table 7.7. The producer perceptions of why graziers are not using integrated weed management against blackberry and serrated tussock are shown in Table 7.6 and Table 7.8.

Each response or issue raised by participants has been categorised using an inferential code. In some cases responses did not fall neatly into any category and are listed as unidentified.

**Table 7.5 The bad features and challenges to individual control methods for blackberry**

| Individual control method | Bad features or challenges | Inferential code |
|---|---|---|
| Spot spraying | Farm labour can be a limiting factor as labourers get bored. Contractors typically do a better job. | Resources and infrastructure |
| | Must run at least one experienced operator with any inexperienced sprayers | Resources and infrastructure |
| | Obtaining seasonal spraying labour can be difficult | Resources and infrastructure |
| | You need a 4wd tractor towing the spray trailer to effectively get to thickets in steep terrain. This is important as most thickets are now in steep country. | Resources and Infrastructure |
| | You need good sprayers and getting and keeping good labour is a problem | Resources and infrastructure |
| | Missed thickets caused through unidentified spray | Observability |
| | No good for very small plants (canes need to be longer than 1 metre) | Unidentified |
| | Label rates are not sufficient (50% more required) | Unidentified |
| Crash grazing | Use after dozing only | Integration required |
| | Sheep trapping (if not dozed first) | Intersystem impacts |
| Aerial spraying | Have experienced some problems with tree defoliation and death | Intersystem impacts |
| | Need to have good accuracy and be able to hover over thickets | Unidentified |
| | Very expensive which would put people off | Profitability and expense |
| | Don't use in timbered areas as you can kill trees | Intersystem impacts |
| Burning | Burn patterns often show burning through the centre of the thicket with the edges of the thickets left unburnt | Unidentified |
| | There are restrictions on when you can burn | Unidentified |
| | Fire getting away can be a problem for some people | Intersystem impacts / externalities |

| Individual control method | Bad features or challenges | Inferential code |
|---|---|---|
| | It doesn't get rid of the blackberries, its more just a management tool | Integration required |
| | Causes seed germination | Intra-system impacts |
| | Can be difficult to get alight | Unidentified |
| Goats | Don't want goats as they can bring in foot rot through escaping through fences | Intersystem impacts |
| | Difficult animal husbandry, hard to handle in races | Resources and infrastructure |
| | Fences need to be good | Resources and infrastructure |
| | Need to slash, doze or burn first | Integration required |
| Jet boom spraying | Does not penetrate dense thickets | Efficacy |
| | Thickets need to have the dozer put through them first | Integration required |
| | Hard to get around (in difficult terrain) | Fixed environmental features |
| Granular herbicides | Velpar® used in past has caused a lot of non target species damage | Intersystem impacts |
| | Granules need to stick to the soil and not spread everywhere when wet | Unidentified |
| Grazing management | Fencing can be a problem | Resources and Infrastructure |
| | Blackberries are not a problem in small paddocks only in the larger paddocks in difficult terrain so grazing management is not that useful | Fixed environmental features |
| Mechanical removal | The machine is very expensive. | Resources and Infrastructure |
| | You need to know how to drive it. | Intellectual demand |
| | For less than 4000 acres you should just call a contractor. | Profitability and expense |
| | It is not good in wet weather. | Climatic variability |

**Table 7.6 The bad features and challenges to individual control methods for serrated tussock**

| Individual control method | Bad features or challenges | Inferential code |
|---|---|---|
| Chipping | Chipping is a waste of time it brings the seed bed to the surface | Intra-system impacts |
| Spot spraying | Spot spraying can get very expensive. Participant identified a shift to boom spraying if too much time is being spent on spot spraying | Profitability and expense |

| Individual control method | Bad features or challenges | Inferential code |
|---|---|---|
| | A good improved pasture and managing the whole issue is more important than just attacking individual plants | Integration required |
| Boom spraying | Four month lockup for boom spraying is not economical for the whole farm | Intersystem impacts |
| | Herbicide resistance is a worry | Unidentified |
| | Flupropanate® badly affects native country | Intersystem impacts |
| | Follow up spot spraying is required to avoid resistance | Herbicide resistance / Integration required |
| Fertiliser | Native country is fine if not fertilised. Fertiliser alone is insufficient, species improvement must be undertaken to control tussock | Integration required |
| Grazing management | Can't reduce stocking rate as there is less money for control | Profitability and expense |
| Spray topping | Why spray top when you can spray to kill | Relative advantage |
| Tree planting | There needs to be some income to offset the lost production from tree lots | Profitability and expense |

**Table 7.7 The challenges to adoption of integrated weed management strategies for blackberry**

| Issue raised by participant | Inferential code |
|---|---|
| Some producers lack the self motivation to get started and implement controls. | Unidentified |
| You need to be persistent to achieve control and not all farmers are. | Unidentified |
| Ideal times for spot spraying clashes with family events around Christmas. | Family and lifestyle |
| Spot spraying is interrupted by other farm activities e.g. mustering. | Operational priorities |
| Neighbouring properties not controlling blackberry and enabling reinfestation. | Externalities |
| There is a lack of control on a regional level. | Government regulation |
| There is an unwillingness to dob mates or neighbours in to weed authorities. | Social networks |
| Weed authorities unable to adequately enforce control as they are unable to issue adequate fines. | Government regulation |

**Table 7.8 The challenges to adoption of integrated weed management strategies for serrated tussock**

| Details | Inferential code |
|---|---|
| Land owners have no knowledge on what to do for serrated tussock. | Extension programs |
| Need one on one help and extension. | Extension programs |
| Extension officers keep changing. We want to deal with the same person for confidence and trust. | Extension agent relationships |

| Details | Inferential code |
|---|---|
| Weeds officers will not advise chemical rates or good contractors due to liability. | Extension agent relationships / government regulation |
| There is confusion on the information presented to farmers on things like the best time of application and rates of herbicide and seed viability. No one agrees on anything (and farmers are) paralysed into in-action by this confusion. | Conflicting information |
| Its hard to integrate everything if you can get a couple of things integrated then you are doing really well. Too many external factors (reference to climate) have an impact. | Complexity / climatic variability |
| Weekenders don't work to the seasons like farmers. | Reason for landholding |
| People need to make a decision to take action. | Unidentified |
| The hardest problem is the seed rain, so no matter what you do yourself some one else may be letting the seed rain onto your property. | Externality |
| Need to use a regulatory approach but also with reason so as not to send people broke as that gets you no where. | Government regulation |
| Inspectors do not return to infested farms to check that controls are being implemented. | Government regulation |
| One participant suggested that every tussock observed should be chipped out. Other participants present disagreed indicating that undertaking this would take too long and prevent them from achieving normal farm tasks. In addition one participant described how undertaking this process of vigilant opportunistic chipping resulted in them becoming depressed. This participant went on to describe how they allocate "days" to tussock control so that they are not constantly thinking about and being overwhelmed by the tussock issue. | Personality |

## IDENTIFYING THE KEY CHALLENGES

The methodology outlined in chapter 3 (Identifying the key producer perceptions, page 91) was used to generate the index scores for challenges to adoption (Table 7.9).

**Table 7.9 The top nine most frequently reported challenges to adoption, ranked by an index of the frequency that inferential codes were reported by respondents to the postal survey and by focus group participants.**

| | Postal survey index score (out of 5) | Focus group index score (out of 5) | TOTAL (out of 10) |
|---|---|---|---|
| Resources and infrastructure | 4.8 | 2.5 | 7.3 |
| Intersystem impacts | 2.2 | 2.5 | 4.7 |
| Profitability and expense | 0.8 | 2.5 | 3.3 |

| | | | |
|---|---|---|---|
| Integration required | 0.0 | 3.0 | 3.0 |
| Government regulation | 0.0 | 2.5 | 2.5 |
| Extension programs | 0.0 | 2.5 | 2.5 |
| Weed ecological influences | 2.2 | 0.0 | 2.2 |
| Beliefs and objectives | 1.2 | 0.0 | 1.2 |
| Climatic variability | 1.0 | 0.0 | 1.0 |

## 7.2 DISCUSSION

The inferential codes developed in the literature review (Table 2.7) and applied to the results provide a framework in which to discuss the results. Some of these inferential codes were frequently reported by graziers as commonly perceived challenges to weed management strategies; other inferential codes were only occasionally reported or not reported at all. As many of these challenges are related, all of them are discussed. However, the most important will be highlighted in the conclusions.

### PROFITABILITY AND EXPENSE

Of the non-adopters of spray grazing, 6.4% reported that the practice was either unprofitable or they lacked the funds to implement it (Table 7.2). The chemical component appeared to be the most commonly reported expense. A similar challenge was identified by Sell *et al.* (2000) for the control of leafy spurge. The descriptive code of "not necessary" reported by 10.6% of non-adopters of spray grazing (Table 7.2) might also be included in profitability and expense. This response may suggest a landholder has never reached a sufficient threshold of weed infestation to warrant the application of this management tool. It would seem important then to understand what the economic thresholds for weeds might be. However, little information is available on the cost of weeds and the benefits of controlling them at the farm level (van der Meulen *et al.* in press, Sindel 2000). Even if producers were to be made aware of the costs and benefits of applying a weed management strategy this alone may not be sufficient to

instigate implementation of a given control strategy (Vanclay 2004; van der Meulen *et al.* in press).

Challenges relating to profitability and expense were rarely reported by adopters and dis-adopters of spray grazing (Table 7.3 and Table 7.4). Adopters, those who intend to continue to use spray grazing, may have established a threshold infestation level for which they consider the practice profitable and only intend to use it when this is reached. For dis-adopters, although profitability and expense were rarely reported as an issue, other commonly reported responses such as intersystem impacts (particularly non-target species damage) would ultimately lead to reduced financial viability of spray grazing.

Aerial spraying and mechanical removal were noted as expensive controls for blackberry (Table 7.5). The cost of extensive spot spraying, lost income through reduced stocking rate for control by grazing management and a loss of productive land to implement tree plantations were identified as profitability and expense challenges for serrated tussock (Table 7.6). However, none of the participants in the focus groups for blackberry or serrated tussock reported profit or expense when asked about why landholders failed to apply control programs (Table 7.7 and Table 7.8). This could suggest expense is of a lower priority amongst other challenges, an idea supported by Vanclay (2004) who has suggested that profit is not the main driving force for innovation adoption. It may also be explained by the possibility that producers do not consider a control that is not profitable to be worth mentioning in the first place.

### RESOURCES AND INFRASTRUCTURE

Non-adopters of spray grazing reported several challenges that are related to farm resources and infrastructure. These were most commonly a lack of suitable spray equipment and fencing

infrastructure (Table 7.2). Similar results were reported by adopters and dis-adopters of spray grazing with stocking rate, fencing and suitable livestock reported as the most common problems (Table 7.3, Table 7.4). Spot spraying of blackberry was reported to be limited by the availability of farm labour skilled in this task. Blackberry control by goats was also limited by the need for increased fencing and a requirement for alternate handling facilities (Table 7.5).

The inclusion of grazing management into a weed management program would appear to be particularly influenced by fencing infrastructure to control stocking rate and the type and availability of suitable livestock. Reeve *et al.* (2000) found that graziers reporting a lack of success in grazing management for weed control attributed it, at least in part, to inappropriate stock type and selective grazing, possibly due to a lower stocking rate.

The issue of farm labour availability appears to be particularly important for weed control. Focus groups highlighted the importance of having trained labour available during peak spot spraying periods. Sell *et al.* (2000) reiterates this point for leafy spurge control indicating that both scouting (paddock checking) and chemical application are limited by labour availability.

The issue of labour availability is not a simple one. Amongst farmers, controls such as spot spraying are regarded as monotonous and hard work. It appears that many landholders avoid these tasks themselves, preferring to employ labour so that they can concentrate on other responsibilities. Where landholders do undertake their own spot spraying, this monotony may be a cause of dis-adoption such as is seen in a lack of persistence or reduced motivation (see "unidentified" responses in Table 7.7). Comments from producers suggest that this monotony leads to increased errors in application amongst farm employees. As a consequence, some producers suggest employing contract labour as they provide a more professional result.

This area of human behaviour needs to be understood further, however the problems with weed control methods which are monotonous might be addressed by specific rest periods for workers or periodical reassignment to different tasks. Whilst this will not sit well with the general farm ethos that you work until the job is done, further research may reveal strategies for labour management that increase the efficiency and retention rate of farm workers.

## ADJUSTMENT COSTS

Adjustment costs are closely related to resources and infrastructure as the adoption of any new weed management strategy that requires new resources or infrastructure may need capital investment. No responses were directly coded as being related to adjustment costs. Despite this, adjustment costs will clearly play an important role in the consideration of implementing a new weed management strategy. The lack of responses in this category might be due to the fact that this challenge is reported as a lack of infrastructure rather than an issue of money and finance. Grazing management was mentioned as being affected by fencing infrastructure and any intensification would be limited by the cost of construction. It is possible that the development of a cheap and effective source of restricting livestock to a desired area of pasture would allow producers to more readily incorporate grazing management practices into weed control strategies.

## INTERSYSTEM IMPACTS

The majority of intersystem impacts amongst non-adopters of spray grazing concerned the perceived impacts of chemicals on livestock, livestock withholding periods and livestock health issues (Table 7.2). The side effects of non-target species damage was highlighted as a particular problem by some dis-adopters of spray grazing (Table 7.3, Table 7.4). Of particular concern to these producers was damage to the legume component of the pasture. A small

number of respondents identified damage to trees by spray grazing, this was also reported by focus group participants as a problem with aerial spraying for blackberry control (Table 7.5). The effect of flupropanate on pastures and the withholding periods for sprayed paddocks were reported as problems for the chemical control of serrated tussock too(Table 7.6).

It is clear from these results that producers are particularly concerned about the impact of weed control methods on the pasture resource and livestock system. This has obvious implications for control methods that although effective, negatively influence other farm systems. This concern for the impact on other farm systems might however be used to advantage. In their research on the adoption of integrated weed management strategies for the control of weeds in cropping systems in the context of herbicide resistant ryegrass, Llewellyn *et al.* (2004) concluded that the promotion of the beneficial impacts of control methods on other farm systems might assist adoption.

## INTRA-SYSTEM IMPACTS

Intra-system impacts was a new inferential code developed to explain responses that reported certain weed management methods that encouraged the establishment of new weeds. The term "intra-system impact" was applied as it describes the effects within the pasture (desirable and undesirable) system, as opposed to "inter-system impacts" which affect other farm systems. In this case and intra-system impact might be the return of the same species as was removed, as was reported for the chipping of serrated tussock or incursion of a new weed species. These responses were only occasionally reported (Table 7.3, Table 7.5, Table 7.6), however they are important as they demonstrate the problems of control methods that remove the target weed without considering what will re-establish in the voided ecological niche.

## FIXED ENVIRONMENTAL FACTORS

Like farm resources and infrastructure, fixed environmental features limit the applicability of weed management strategies to certain properties. A large proportion (7.5%) of non-adopters of spray grazing reported their reason for having not used spray grazing as the terrain being too steep or rocky (Table 7.2). Difficult terrain was also identified as a challenge for the application of several blackberry management methods (Table 7.5). The control of leafy spurge in the United States has also been reported to be limited by difficult terrain (Sell *et al.* 2000).

Some of these non-adopters identified aerial application as the obvious solution. However both these non-adopters, and producers surveyed in other studies, have reported this. technique as being too expensive (Sell *et al.* 2000; van der Meulen *et al.* in press). This is probably a result of the marginal profits being gained from areas with steep and rocky topography. Weed control in difficult terrain has been a constant problem for graziers. Research is needed so that strategies can be developed to target these areas.

## OPERATIONAL PRIORITIES

The challenge of operational priorities is closely related to the labour component of farm resources and infrastructure. Of non-adopters, 3.5% reported a lack of time as the reason for having not taken up spray grazing (Table 7.2). The spot spraying of blackberries was also reported as being interrupted by other farm activities, particularly livestock movements (Table 7.7). It is becoming apparent that as a priority weed management probably sits below animal husbandry tasks, which are seen as amore urgent (van der Meulen *et al.* in press). In addition to this, it is expected that producers see some farm tasks as more personally desirable or

rewarding than others. It is thought that many weed management tasks will not rank highly on this scale and will therefore not be afforded a high priority.

## COMPLEXITY

An integrated weed management strategy is by its nature somewhat complex. However, some strategies are going to be more intricate than others, incorporating a varied number of individual controls that might be influenced by any number of factors. The variety of reasons that respondents gave for having not adopted spray grazing and the diversity of problems encountered by those that have adopted it, highlight this complexity inherent in weed control strategies. Although spray grazing integrates only two control methods, the issues presented by respondents touch on every system within an agricultural operation. In particular reference to this complexity, one focus group participant stated "it's hard to integrate everything, if you can get a couple of things integrated you are doing well". Clearly, some producers are going to be able to cope better with complexity than others. van der Meulen *et al.* (in press) identified a demographic of graziers for whom complex weed management strategies may never be suitable. The solution offered by van der Meulen *et al.* (in press) was to encourage the diligent application of simple controls.

## DIVISIBILITY

Divisibility is the ability of an innovation to be broken down and its components trialled or applied individually. As a challenge to adoption of spray grazing or any other control methods, divisibility was not directly reported by any respondents. Despite this, divisibility will be an important contributor to the application and particularly trial of a weed management strategy. This will be particularly true for more complex integrated weed

management strategies where the ability to trial or apply individual controls will increase the likelihood of adoption.

This might also suggest that integrated weed management strategies where the success of each individual control is dependent on the application of another may be less likely to be adopted. This may be seen in the link between divisibility and the inferential code described as "integration required". For a few control methods for both blackberry and serrated tussock focus group participants reported that they required integration for success (Table 7.5; Table 7.6). The fact that some of these methods cannot be individually applied or trialled to examine their efficacy increases the complexity of adoption. If integrated weed management strategies are to be promoted to producers any inter-dependence of individual control methods will need to be clearly communicated.

### TRIALABILITY

Being able to trial or apply a control method on a small scale were not reported as challenges by respondents in any of the case studies examined. It is thought that all three case studies, - spray grazing and the controls for blackberry and serrated tussock - are relatively trialable. Most of them can be applied on a small scale and don't require full scale adoption for success.

An expected although interesting result is that perceived failure of the trial or use of a control method does not limit the continued use or further trial. Of those respondents reporting a perceived failure of spray grazing, 47.5% indicated that they would use it again (Table 7.1). This supports the trialling and up-skilling model described by Abadi Ghadim and Pannell (1999). This finding provides some hope for the extension of weed management strategies that require some trial and error in the specific application to a property. As long as the

challenges causing failure are perceived as surmountable then it is expected that the producer will continue to adapt the management tool.

## OBSERVABILITY

The observability of results was rarely reported as a challenge for spray grazing. Some research suggests that chemical controls set a benchmark of efficacy and therefore possibly observability. Producers then use this benchmark as a point of comparison for the effectiveness of other controls (Llewellyn *et al.* 2004). Although spray grazing uses only a sub-lethal dose of herbicide, its success is readily observable by the change in weed habit and subsequent defoliation under grazing.

Both the blackberry and serrated tussock focus groups brought to light an issue with the slow working nature of some herbicides. Flupropanate (Taskforce®) for serrated tussock and metsulfuron-methyl (Brush-off®) are slow working herbicides taking weeks or months before the targets show symptoms of poisoning. The addition of glyphosate to the mix for both these herbicides has been reported to enable visualisation of the results. Whilst this practice is partly functional in that it allows the producer to check for missed weeds it is also thought to be a psychological issue for some landholders who want to see observable results. The practice of mixing glyphosate with selective herbicides has been suggested by some producers to lesson its efficacy. In addition, some more effective herbicides may not be being used as it takes too long to be able observe the results.

Clearly the observability of a weed management strategy plays an important role in its adoption. This issue may be of particular relevance to weed quarantine strategies where results are rarely observable. The promotion of quarantine strategies may require the implementation of some form of observable measure of success.

## TIME SCALE

Observability is closely related to the time scale on which the innovation works. Weed controls can be both long or short term, and integrated weed management strategies are frequently a mix of both. Like observability, few if any responses related to the challenge of time scale. Again this may reflect the more short term observable controls reported on in this study. There may be a link between time scale and the idea of persistence. Some weed management strategies require repeated application over many years to achieve a desired outcome (eradication or reduction to a manageable density). This effectively increases the time scale of a weed management strategy. Although a producer may understand the need for repeated control over many years, if the practice fails to deliver observable results each year its chances of dis-adoption may be increased.

The planting of trees for the management of weeds is one particular control that suffers from an extended time scale. Tree planting is recommended for the control of serrated tussock, however the long time scale and need to undertake spot spraying in areas underneath trees until they are established is probably one of the leading causes of non-adoption of this practice.

## FLEXIBILITY

Producers in this study did not highlight flexibility as a challenge for the adoption of weed management strategies. It is thought that the particular management strategies examined in this study, spray grazing and controls for blackberry and serrated tussock, do not appear to restrict the ability of producers to change their enterprises.

Despite this, some weed management strategies will have a significant impact on flexibility. A good example is the planting of trees for serrated tussock control. In this case the land is

effectively locked up reducing the ease with which a landholder might be able to change the use of the land under plantation. It is thought that many producers considering the implementation of tree plantings isolate these to the most marginal country so that they are less concerned with the potential loss of flexibility.

### INTELLECTUAL DEMAND

The intellectual demand or amount of additional learning required to implement an innovation is related to its overall complexity (Vanclay 2004; van der Meulen *et al.* in press). In comparison with other controls, spray grazing can be considered a relatively complex weed management method. Although responses were only infrequently coded as related to intellectual demand, many producers will have had to go through the process of learning the technique of spray grazing and it may have been a stumbling block for some. Clearly certain demographics are going to be more capable of learning and applying complex weed management strategies than others (van der Meulen *et al.* in press).

### RELATIVE ADVANTAGE

Relative advantage describes the overall advantage of a weed management strategy over any existing control methods. This inferential code was used to classify any descriptive codes, falling into this area that could not be classified otherwise. These challenges varied but generally suggested that the control method examined was less effective than other methods.

### EXTERNALITIES

Externalities, spill-overs or issues of commons, are important issues in natural resource management. The issue of externalities was brought up by participants in both the blackberry and serrated tussock focus groups (Table 7.7, Table 7.8). In both cases the lack of control on neighbouring properties was identified as an issue. This is not an isolated problem with

similar issues having been reported by Sell *et al.* (2000) for leafy spurge in the United States and for other pasture weeds in Australia (Rush 1996; Sindel 1996; McLaren *et al.* 2002b).

Participants from the focus groups suggested that producers' lack of control over seed incursion (by wind for serrated tussock and animals for blackberry) was resulting in them giving up attempts at control. For serrated tussock in particular, participant perceptions indicated that these producers considered that all their attempts at control were negated by constant reinfestation. They were being overwhelmed and ultimately abandoned control strategies.

It is not clear to what extent this situation of complete dis-adoption of controls might be happening. However, it is clear that some producers suffer a great deal of anxiety from weed externality problems. The issue of externality for salinity has been addressed by Pannell *et al.* (2001). These authors suggest that innovations for the management of salinity have suffered a poor adoption rate because of producer perception of salinity as dominated by issues of externality. The traditional views held by landholders were that salinity was caused by others and any management strategies they imposed may benefit others and not necessarily themselves.

The same may be true of externality issues in weed management. Little information appears to be available to farmers to quantify the effects of seed rain. If landholders were to find that only a small proportion of seed was coming from off-farm then they may be less likely to be overwhelmed and more likely to take responsibility and control those plants producing seed on their own property. Conversely if seed rain was found to form a large proportion of the weed seed found on a farm they may make the economically reasonable decision to reduce management intensity. In this case the availability of sound ecological information might

enable policy makers to institute suitable regulations and economic incentives to encourage management on a regional basis.

## GOVERNMENT POLICIES

Challenges relating to government regulations were reported by focus group participants for both blackberry and serrated tussock (Table 7.7, Table 7.8). Both of these weeds carry noxious weed status in several states with laws stipulating certain degrees of control be applied. In both cases, the landholders felt that there was inadequate monitoring, enforcement and penalties for producers not controlling these weeds. Similar results were reported for the control of leafy spurge in the United States (Sell *et al.* 2000). This lack of enforcement of noxious weed legislation is seen by many producers as the cause of the externality problems.

## CLIMATIC VARIABILITY

Seasonal climatic conditions were identified by a small number of non-adopters of spray grazing as their reason for having not applied this control (Table 7.2). In most cases these responses related to the occurrence of drought. Poor seasonal climatic conditions were also reported as a problem by adopters of spray grazing (Table 7.3, Table 7.4). This study has previously reported that some producers deliberately avoid spray grazing when seasonal conditions are poor as the weeds provide valuable fodder during these times (Revell *et al.* 2002). Climatic variability at the time of spraying has also caused problems for adopters of spray grazing. A variety of climatic events such as rainfall, wind and high or low temperatures were identified. Climatic conditions were specifically identified as causing problems with the integration of weed management strategies by participants in the serrated tussock focus group (Table 7.8). In this case the participants reported that climatic variability, particularly drought, would override their attempts to implement an integrated approach to control.

Reeve *et al.* (2000) identify drought as an obstacle to the adoption of grazing management strategies and suggest that extension strategies need to focus on the opportunities that droughts might provide for pasture manipulation. This might also be the case for weed management in general, with droughts providing specific opportunities for weed management. Set against these opportunities are the devastating financial, physical and emotional effects of drought. There is a need for further research into management of weeds in response to drought.

## EXTERNAL INFRASTRUCTURE

External infrastructure was mentioned as a challenge to the adoption of weed management strategies by only one landholder. This respondent reported a lack of availability of spray contractors. A similar problem was reported by Sell *et al.* (2000).

## BELIEFS AND OBJECTIVES

Of non-adopters of spray grazing, 10.6% identified an aversion to chemicals as the reason they had not used this control. A further 4.2% of non-adopters reported that their reason for having not used spray grazing was that they were organic farmers (Table 7.2). Chemical aversion was also highlighted as an issue for producers with a minimalist weed management approach in research undertaken by van der Meulen *et al.* (in press). If a weed management strategy involves controls that are not compatible with a landholder's personal beliefs and farm objectives, it is unlikely to be adopted.

A closely related challenge identified by Pannell *et al.* (2006) was brand loyalty and self image. Although not formally identified in the focus group, one participant later spoke about his personal experience of having to change from a stud sheep breeding operation to a cattle-only enterprise to facilitate better serrated tussock management. In this case, despite the sheep

stud being a family tradition for many generations the producer overcame this challenge of brand loyalty and self image (of being a stud sheep breeder) to adopt an enterprise which allowed better pasture management for weed control. Despite this producer being willing or forced by circumstances to undertake such a drastic change, it is thought that many producers would find similar adjustments a difficult challenge.

## SOCIAL NETWORKS

The only direct suggestion of the influence of social support networks found in this study was reported by participants in the blackberry focus group (Table 7.7). Producers were unwilling to report neighbours with high level infestations, despite these neighbours being seen as a constant source of reinfestation. Producers were unwilling to report their neighbours for fear of social repercussions. The positive influence of social support networks on innovation adoption is reported by many authors (e.g. Vanclay 2004; Pannell *et al.* 2006). Despite not being reported in this study, it is expected that the development of strong social support networks will assist in the adoption process for weed management strategies.

## FAMILY AND LIFESTYLE

The optimal control of blackberry was reported as being affected by family commitments. The best time for blackberry control for some producers falls over the Christmas holiday period. As a result, spot spraying is often abandoned during this time. The impacts of this abandonment on the long term control of blackberry are unclear. Also unclear are the effects on weed managers of having key or peak management times interrupted by other tasks. It is possible that this might demoralize some producers.

Although remaining unmentioned in the results it is important to note the influence that family members, other than the main decision maker or labourer, can have on weeds. Whilst

the male member of the farming family is traditionally seen as being in charge of weed management it was apparent that wives and children are also frequently involved as either decision makers or labourers.

## PERSONALITY

Pannell *et al.* (2006) suggest that personality may play a role in the adoption of sustainable land management practices. The only response coded as personality was by a participant in the serrated tussock focus group. The participant reported personal problems with depression from having to deal with an ever increasing serrated tussock infestation. This is a compelling example of the influence that weeds can have on the mental health of landholders. These psychological issues are well documented for other agricultural issues such as Johnes disease in sheep (Hood and Seedsman 2004), however little information is available in this area in relation to weeds. The participant indicating this problem reported a strategy of focussing on serrated tussock on certain allocated days as a means to avoid becoming overwhelmed. Further investigation into strategies such as these may assist other producers facing similar problems.

## REASON FOR LANDHOLDING

The reason for holding land was reported as an issue by focus group participants (Table 7.8). In this case small block holders who owned land for lifestyle purposes were suggested as facing unique challenges in terms of weed management. It was suggested that small block holders were unaware of when to undertake control methods as they were not attuned to the seasons. Many large production focussed landholders are increasingly identifying small block holders and absentee landlords as the cause of main externality issues of weed seed incursion.

Similar issues were reported by landholders regarding the control of leafy spurge in the United States (Sell *et al.* 2000).

### LAND TENURE AND OWNERSHIP

Although not directly reported as an issue by respondents in this study, land tenure has been found to influence land management (Carolan 2005) and more specifically weed management decisions (Sell *et al.* 2000).

### EXPECTATIONS OF FUTURE INNOVATIONS

Llewellyn *et al.* (2005) identified that grain grower expectations of the time until availability of a new chemical control influenced the adoption of other weed management strategies. Although this trend was not directly reported by producers in this study, similar problems may well exist amongst graziers. During this project I have spoken with many graziers who are hopeful of the release of biological control agents for certain weeds. It would be reasonable to assert that a grazier's perception of the time until release and expected effectiveness of a biological control might influence the adoption decisions of other weed management strategies.

### HERBICIDE RESISTANCE

A small proportion of non-adopters of spray grazing reported concerns about inducing herbicide resistance. This issue was also raised in the serrated tussock focus group where producers identified herbicide resistance as a problem with boom spraying of flupropanate. Llewellyn *et al.* (2005) reported the presence of herbicide resistant ryegrass as an inducement to the adoption of non-chemical controls. The results from this study also suggest that producer perceptions of potential herbicide resistance will influence the adoption of weed management strategies that incorporate non chemical control.

## DEMOGRAPHIC AND FARM CHARACTERISTICS

Age, education, off farm income and property size were not explicitly reported as challenges to adoption of weed management strategies. Despite this, they will obviously interact with many of the challenges perceived as important by producers. The work undertaken by van der Meulen *et al.* (in press) has explored these areas in depth and demonstrates the importance of demographic and social factors in understanding weed management amongst graziers.

## EXTENSION PROGRAMS, EXTENSION AGENT RELATIONSHIPS, THE AVAILABILITY OF INFORMATION AND CONFLICTING INFORMATION

Producers in the serrated tussock focus group reported several issues relating to the issues of extension and information (Table 7.8). Participants perceived that in some cases the current extension programs were inadequate with some landholders having little knowledge of how to control serrated tussock. Where information was available participants reported that many landholders were faced with conflicting guidelines, a problem highlighted by Vanclay (2004). Participants described the importance of extension agent relationships, an issue also identified by Pannell *et al.* (2006) as important in successful extension programs.

## ANTICIPATION AND OBSERVATION OF THE PROBLEM OR OPPORTUNITY

The design of this study made it difficult to capture information relating to the ability of graziers to anticipate or observe weed problems. Despite this fact, it is an important issue. A landholder's perception of weediness of any species will obviously influence their intensity of control attempts (Rush 1996). This issue is complicated by the fact that there appears to be little information of the economic cost of many pasture weeds (van der Meulen *et al.* in press). The temporary benefits provided by some weed species should not be underestimated. In conversations I have had with producers it is not uncommon for them to admit leaving one

or two blackberry bushes to allow a harvest of their berries for personal use. These temporary benefits provided by some weedy species have previously been reported as limiting their control (Munyasi *et al.* 2003).

There is clearly a need for landholders to be provided with information on the costs of weeds at different densities on their property. Enabling farmers to quantify the financial losses due to lost production will be important to allow the determination of thresholds and making rational management decisions. Short term production economics are not the sole driver of adoption (Vanclay 2004), producers could also benefit from estimates of other costs such as property values and those costs found in externality issues. If a farmer was informed that the weed seed produced on their farm and blown onto neighbours, properties was costing their neighbours a certain amount in lost production and control it might influence their decisions. This information can only come about through detailed ecological studies coupled with sound economic analysis, and this research is neither simple nor cheap.

## 7.3 CONCLUSIONS AND IMPLICATIONS FOR INNOVATION AND TRANSFER

Producer perceptions of the relative importance of challenges to adoption of weed management are listed in Table 7.9. Amongst all the weed management strategies investigated in this study the most commonly reported challenges involved resources and infrastructure, intersystem impacts and profitability and expense. Focus group participants also commonly identified the challenges of integration, government regulation and extension programs. Postal survey respondents reported the challenges posed by weed ecological influences, beliefs and objectives and climatic variability.

The results produced in this study will be specific to the control methods examined. Other researchers examining similar problems have identified a different order or priority of challenges (e.g. Llewellyn *et al.* 2004). It is important to note that the challenges identified are producer perceptions. This means that many of the challenges listed as being reported less frequently are not necessarily less important. In fact, many play key roles in the innovation adoption decision process. Despite this the producer perceptions of the most commonly reported challenges provide a valuable check list for organisations and individuals involved in the innovation and transfer of weed management strategies.

Table 7.10 lists the questions that might be asked of a weed management strategy targeted at graziers derived from the top nine most commonly reported challenges. The themes of relative advantage and trialability proposed by Pannell *et al.* (2006) become apparent in these questions. Many of the questions drive at either the overall relative advantage and the problems that might limit this or the challenges to trialling or applying a weed management strategy on a small scale.

The questions presented in Table 7.10 can be used to guide the development and transfer of weed management strategies. The responses to these questions along with suggestions for overcoming challenges may prove a valuable addition to any extension literature or information. The book Pasture Management for Weed Control (Burton and Dowling 2004) provides an example of extension material that presents some of these challenges. With reference to spray grazing, this publication identifies the problem of non target species damage and that of weed ecological influences of staggered germination and provides suggestions for overcoming it. Despite identifying these important problems many other challenges reported by respondents in this study could be added to extension literature along with suggestions for overcoming them.

Innovation adoption is an important issue that continues to grow in significance in the ever changing world of research and development. All participants in the innovation, transfer and adoption process need to gain a better understanding of their roles and the potential challenges they face. If weed researchers are to act as effective innovators they need to develop an understanding of the challenges that adopters will face in attempting to implement their strategies. The challenges identified and discussed in this study and the questions posed in this chapter have begun to elucidate the issues and provide a framework in which innovators can work. However, much more research is required to fully understand the challenges to adoption of specific weed management strategies amongst landholders. Still further study is required to assist in the development of techniques to enable the great variety of landholders to overcome these challenges.

Many of the authors reviewed for this chapter have pointed out that adoption of weed management practices is a dynamic and ongoing process. This study has demonstrated that the challenges that exist are diverse and have complex relationships. Looking for ways to overcome the challenges to weed management that have become apparent in this study must be the next step. However, when one considers that all farmers are unique it becomes difficult to provide prescriptive answers to the problem of adoption of weed management. An increased awareness of the value of local knowledge and an increased ability to capture and assess it may well be a step in the right direction.

**Table 7.10 The top nine producer perceived challenges and related questions that innovators or transfer personal might ask concerning a weed management strategy, the answers to which might prove valuable for inclusion in extension material.**

| Challenge | Questions for innovators or transfer personal to ask |
|---|---|
| Resources and infrastructure | What extra resources or infrastructure will be required to implement this weed management strategy? What is the cost of these?<br>Is there a way of using or modifying current farm resources or infrastructure to allow trial or small scale adoption?<br>What are the labour requirements in time and skills for this weed management strategy?<br>How monotonous is this weed management strategy?<br>Do target producers have suitable livestock classes to enable control?<br>Do producers have suitable fencing infrastructure to facilitate implementation?<br>Is there a simple and cheap way of fencing to allow trial or partial adoption? |
| Intersystem impacts | What are the possible adverse effects of this weed management strategy on livestock and what are the chances of these occurring?<br>What are the possible adverse effects of this weed management strategy on desirable pasture species and what are the chances of these occurring?<br>Are there any possible benefits that might be gained in other farm systems from implementation? |
| Profitability and expense | Is this weed management strategy profitable in the short, medium or long term?<br>Can you quantify the economic benefits of implementing this weed management strategy?<br>Can you identify a density of weed infestation at which this weed management strategy becomes profitable? |
| Integration required | Does this weed management strategy require additional control processes for it to be successful? These will require review as well!<br>Does this weed management strategy integrate several complex control methods? (if so, it may not be extendable to all land managers).<br>If this weed management strategy integrates several controls are they independent of or interdependent on each other for success? Integrated weed management strategies with a high level of interdependent controls are less trialable. The adoption of IWM strategies with independent controls might be encouraged by trial of the individual controls. |
| Government regulation | How might government regulations affect the implementation of this weed management strategy? (Although largely out of the control of the innovator or transfer personnel changes in legislation and its enforcement might be used to advantage in encouraging adoption)<br>(In the case of this study, government regulation and externality issues go hand in hand. Leading graziers will be interested in how a weed management strategy might assist in their externality issues) |

| Challenge | Questions for innovators or transfer personal to ask |
|---|---|
| Extension programs | Although this study does not focus on providing details for a successful extension program producers highlighted two key issues:<br>Innovator and transfer personal relationships are important, how can you establish or use existing relationships? and,<br>Conflicting information is a problem, what other information has already been extended or what myths exist? These will need to be dealt with in extension programs. |
| Weed ecological influences | What are the ecological strengths of the target weed? How might it overcome this weed management strategy? When producers are armed with this information they will understand control failures, be less likely to dis-adopt and innovate around them. |
| Beliefs and objectives | How does this weed management strategy fit with grazier's personal beliefs and objectives?<br>(Understand that graziers have personal values and subsequent farm objectives that are not entirely economically driven)<br>For IWM strategies that incorporate herbicides is there an alternative non-chemical control that can be applied with comparative success for those formally or informally organic growers? |
| Climatic variability | How will drought affect the viability of this weed management strategy?<br><br>How might short term climatic conditions (e.g. extreme temperatures, rainfall and frost) affect the implementation of parts or all of this weed management strategy? |

# 8 Conclusions

This project has gathered an enormous amount of information from producers on the management of pasture weeds in southern Australia, only some of which has been presented here. The broad aims of this thesis were to: 1) examine the validity of producer perceptions; 2) identify producer perceptions of the most important pasture weeds in southern Australian pastures; 3) identify the best weed management practices currently being used by graziers; and 4) examine the challenges to the adoption of these control methods.

## 8.1 VALIDATION OF PRODUCER PERCEPTIONS

Both biological and economic studies are often based on survey information and so it is imperative that an understanding is gained of the ability of producers to accurately report weed infestations. Although the study undertaken to validate a sub section of the postal survey results was preliminary in nature the results indicate that producers can usually quantify weed canopy cover to within 5% in their own paddocks. However, for some weeds the results may be less accurate. The reporting of the annual grass vulpia (*Vulpia* spp.) was plagued by the inability of producers to accurately identify this weed. Whilst credence should be given to producer perceptions of the density of weeds for most species, especially broadleaf weeds, studies using self reported data on vulpia and other "non-descript" annual grasses should be treated with caution.

One of the most convincing reasons for developing validation studies is the possible spin offs it might have for producers. If the ability of graziers to identify and quantify the weed species occurring in their paddocks can be measured, then steps can be put in place to improve their skills in this area. If producers can become effective assessors of the density of weeds in their pasture then they may be able to use this information to make more rational economic decisions about weed management. Ultimately, as computer models become available,

producers may be able to assess a pasture paddock, and enter densities for a range of species into a program that will simulate the potential losses from these weeds and the benefits from various control options.

## 8.2 PASTURE WEEDS OF SOUTHERN AUSTRALIA

Whilst the respondents in this project demonstrated many similarities with the general farming population, it is likely that they will have been dominated by graziers interested in weed issues. They reported an estimated 328 plants as undesirable species, dominated by annual broadleaf weeds. The most commonly reported species included capeweed, Paterson's curse, saffron thistle, blackberry and barley grass. Whilst reported by fewer respondents, several perennial grasses - Coolatai grass, Chilean needle grass and *Sporobolus* spp.- were suggested to be key increasing problems for graziers. Viper's bugloss was also reported as an increasing problem. Apart from barley grass, the annual grasses appear to be under reported by graziers.

## 8.3 BEST MANAGEMENT PRACTICES

Due to their high rate of reported occurrence, capeweed, blackberry, barley grass and serrated tussock were chosen for assessment of their best management practices.

### CAPEWEED

The results suggest that the strategic integration of control methods is being undertaken by some graziers and is probably the best means of managing capeweed. For extensive and established infestations spray grazing should be used, however this short term control needs to be followed up with grazing management and other proactive controls to promote pasture competition. Where fencing infrastructure limits the application of spray grazing lethal dose

boom spraying should be applied. Paddocks should be checked regularly in autumn so that timely winter cleaning can be carried out and if capeweed does establish and infestations are allowed to go to flower pasture topping may provide effective results. If the land is arable paddock rotations and the sowing of pastures may be successful. Spot spraying will be of use to those producers struggling with new incursions or small infestations. The key to successful control of capeweed appears to be the integration of proactive and reactive controls in a strategic way to control established infestations and reduce future establishment through pasture competition.

## BLACKBERRY

The results suggest that the strategic integration of control methods for the control of blackberry may not provide as much benefit as for other weeds. Essentially the diligent and regular application of spot spraying may be sufficient to provide success in blackberry control, particularly in rugged terrain where the implementation of proactive controls such as grazing management and the sowing of pastures is limited. However, the cluster with the greatest proportion of respondents reporting a decreasing blackberry problem were those graziers integrating a range of proactive pasture promoting controls. Burning is integrated with success as both a pre-spraying operation to reduce thicket size and post-spraying to reduce the standing dead thicket. Producers are keen to see the release of a selective residual herbicide in granular form to allow for easy to application and ongoing control for re-establishing thickets.

The key to the successful control of blackberry appears to be the diligent and persistent application of spot spraying and where possible the strategic integration of burning and proactive control methods.

## BARLEY GRASS

The integration of control methods for barley grass would appear to be the best strategy for the management of this weed. Respondents have repeatedly reported the need for competitive pastures to control barley grass. This will be achieved through grazing management and the promotion of competitive species. If established pastures do become infested with barley grass, the reactive control methods such as boom spraying, winter cleaning, pasture topping and spray grazing should be considered. Producers should pay particular attention to the opportunities that the establishment of new pastures or crop rotation provides for the control of barley grass. The key to the successful control of barley grass appears to be maintaining a competitive pasture.

## SERRATED TUSSOCK

The best integrated weed management strategy for serrated tussock will vary from farm to farm. For producers facing extensive infestations, the diligent application of spot spraying and opportunistic chipping will provide good results. However, this will be of little value in the absence of a competitive pasture, maintained through grazing management, species manipulation and fertiliser application. Larger infestations on arable land may be successfully treated through the establishment of a sown pasture. Boom spraying, cultivation and crop rotation may be valuable components of this process. For those producers facing more isolated infestations the key to success will be the continued monitoring and control of infestations. Facilitating opportunistic control by chipping or small dose chemical applicators is an important component of control of serrated tussock when it occurs infrequently.

The overall key to serrated tussock control appears to be the maintenance of competitive pastures and the diligent monitoring and control of isolated infestations.

### OVERALL BEST MANAGEMENT PRACTICE FOR WEEDS OF PASTURES

Producers that incorporate both proactive and reactive controls appear to have more success than those reliant on only reactive controls. Many of the clusters identified in this study that were identified as pasture promoters or more likely to use proactive controls were repeatedly populated by more respondents reporting a decreasing weed problem. Despite the apparent effectiveness of these proactive controls, it is essential to realise that most producers strategically integrate these with reactive controls to deal with established infestations or new incursions. In many cases the effectiveness of reactive methods appears to be linked with the diligence and regularity with which the control is applied. However, proactive controls also suffer if not regularly and diligently applied. Persistence in pasture weed control is a key factor in success.

## 8.4 CHALLENGES TO ADOPTION

The key challenges to the adoption of weed management strategies identified in this study included: resources and infrastructure limitations; the impact of the control on other parts of the farm system; a reduced profitability or expense involved in the control, or the availability of funds; the requirement for the control to be integrated with other methods; the influence of government regulation; a lack of extension programs; weed ecological influences; an incompatibility of the control with the beliefs and objectives of the producer; and climatic variability. An understanding of these challenges is of prime importance to researchers and extension agents seeking to promote weed management strategies. The following questions are the minimum to be asked in considering the adoption challenges of a new management strategy. What resources or infrastructure will be required for a producer to implement this

strategy? What are the possible adverse effects of this control on other farm systems, particularly livestock? Is this weed management strategy profitable?

## 8.5 FURTHER RESEARCH

This project has used producer knowledge to examine the best management practices for pasture weeds. The use of local or indigenous knowledge in developing countries is widespread and relatively well developed (Raedeke and Rikoon 1996; Walker *et al.* 1999). In contrast, its use in western cultures lags well behind developing nations (Millar and Curtis 1999). The local knowledge harvested through this study has proven very beneficial and so it is reasonable to assume that the same process could be applied to many other areas of agricultural research. However, the science of harvesting local knowledge, particularly in western cultures is lacking. Research is needed to develop techniques that can be applied across the fields of social and biological science so that the information collected is as accurate as possible.

This study has examined the innovation and adoption component of pasture weed management. In particular it has taken an alternative approach to innovation and examined the possible challenges to adoption. What remains unstudied is the transfer component of the innovation, transfer and adoption model. It would be well worth while examining the issues surrounding the transfer of pasture weed management innovations. In particular, information gathered from producers through studies such as this may require a unique transfer process to maximise its application.

There remains a great need for detailed ecological studies of many pasture weeds. This project has demonstrated the value of local knowledge, however this process has its limitations and empirical research into the ecology and management of many existing and emerging weeds is

urgently required. Results of such studies could contribute to another great need in weed research. Economic thresholds need to be developed for weed management in pasture systems. This fact has been reiterated by other authors (Revell *et al.* 2002). One of the key challenges to adoption of weed management strategies identified in this study was profitability and expense. However, little is known of the actual cost of weeds at the paddock level. Additionally, how producers decide what is a financially viable control is still not well understood.

This project has presented information produced through an examination of producer local knowledge. Whilst many researchers in this field baulk at the suggestion of making direct comparisons of producer knowledge with information from empirical scientific research (Millar and Curtis 1999 Leeuwis 2004), they agree that the amalgamation of the two can provide great benefits. Further research could examine ways in which the results produced in this study might be complemented by the relevant scientific literature. Indeed, the products of this process could prove highly valuable to both producers and researchers.

## 8.6 THE FINAL WORD

### TO FARMERS

Integrate proactive, pasture-promoting management strategies with reactive controls where necessary. Know your weeds. Practice quarantine, containment and monitoring strategies. Be diligent in the application of control methods. Look at what other farmers are doing. Don't wait for researchers to come up with solutions. Somewhere, a farmer probably already has one!

### TO RESEARCHERS

Farmers have a great deal of experience in dealing with weeds. Although it is difficult, the harvesting of their knowledge can provide great insights into weeds and their management. Researchers need to take advantage of opportunities to interact with farmers. Researchers and extension personal need to realise that farmers face many challenges in their attempts to manage weeds and take these into account when developing their research.