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Pasture Weed Impact Calculator Scoping Study

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Abstract

A scoping study, involving literature and web review, telephone surveys and focus groups, was undertaken to assess the need, format and benefits of having a pasture weed impact calculator for southern Australia temperate grazing systems to underpin a compelling case for control. Through the telephone survey and focus groups it was clear that there was strong demand for and important benefits of a calculator. Graziers particularly recommended that the impact of weed infestation (measured in % weed coverage and identified through representative photographs) on pasture production be translated into direct economic measures. The extensive review of literature showed that there is minimal pasture-weed impact data currently available at a farm or paddock level. However, such information was reported to assist graziers in weed control decision making and encourage control. The literature review also demonstrated the positive effect weed impact data would have on grazier's motivations and barriers to weed control and the grazier's pest management decision making. Of the graziers surveyed, 98% reported that they would be motivated to control weeds if a significant impact to grazing operations was demonstrated. With graziers made more aware of the impact weed infestations have on their production, this will lead to improved weed control planning and action. The findings support the development of a project subsequent to this scoping study to gather weed impact data at a farm or paddock level, develop communication and extension material and a pasture weed impact calculator. These recommendations would produce a new motivational tool to increase weed management by graziers, including the more reluctant weed managers. This change in practice would be achieved by demonstrating to graziers the direct link between weeds in the paddock, at different % coverage levels, and the impact on their stocking rates and pasture production. The benefits to industry, of having a pasture weed impact calculator, include increased weed control and reductions in weed spread, increased pasture production/stocking rates, and an improvement in livestock health.

Executive Summary

This scoping study was undertaken to scope the demand, benefits, need and format of a pasture weed impact calculator for use by graziers and their advisors in temperate southern Australian grazing systems, to underpin a compelling case for control. While there are generalised economic figures that show the enormous overall cost of weeds to the grazing industry, information is lacking on the specific costs/benefits of individual species or functional weed groups at an individual farm or paddock level, which can drive adoption of weed control by graziers. At present, when a grazier walks out into a paddock with an infestation of a particular weed species at a particular density, he/she is unable to reliably state what impact that weed has on potential production of their pasture and livestock operation in physical or financial terms, and whether control of the weed will increase or decrease profitability, given the cost of control.

Literature was extensively reviewed to determine what weed impact data at a farm or paddock level was currently available – based on Australian or overseas data. Furthermore, literature pertaining to pest management decision making and adoption of new technologies was reviewed as well as information on motivations and barriers to weed control. A web review of available pasture weed impact calculators was also undertaken – currently only overseas based models are in existence.

A cross-sectional telephone survey was conducted with graziers and weed advisors from southern Australia to test the potential demand, format and benefits of a pasture weed impact tool. Of the graziers surveyed, 92% reported that they have difficulty in estimating the costs of weeds in a paddock to grazing operations, and 93% reported that it would make weed control decisions easier on their property if they had more accurate information on the costs to grazing operations of each weed species. A total of 98% of grazier respondents reported that they would be motivated to control a weed if it was demonstrated to be causing significant economic impact and 75% of graziers said they would use a computer model which detailed farm or paddock level weed impact. Some 20% said that they were unsure about using a computer based tool and more than half of these said they would prefer paper based versions of such information.

Two focus groups were held towards the end of the project, i.e. after the completion of literature and web review and telephone surveys. One focus group was comprised of producers and the other was made up of weed advisors. The focus group participants received information on the background to the project and the nature of the scoping study, summary survey results, and a demonstration of the invasive weed impact calculator developed by the United States Department of Agriculture. User feedback was also received on this model. Input was sought from the focus group participants in regards to the format and content of any pasture weed calculator for southern Australia temperate regions and also the method for determining which weeds and regions should be included (or prioritised) in any calculator, and what are the recommended next steps to this scoping study.

If this project is progressed beyond a scoping study, the outcomes will assist graziers make more informed decisions on weed management and, if significant production losses are demonstrated through weed impact data at a farm/paddock level, will provide a compelling case for control, moving otherwise disinterested landholders to increase the feed supply, reduce production loss risks, stop the spread of invasive weeds, and increase their monitoring and assessment of pastures. An increase in weed control in southern Australian grazing systems will have benefits to industry and the environment – with increased stocking rates and a reduction in weed spread.

Strong demand for pasture-weed impact data at a farm or paddock level was clearly demonstrated through the literature review, telephone survey of graziers and their advisors and

focus groups. The literature review showed that such data are limited, albeit important for weed control decision making and grazier motivation to control weeds. The survey demonstrated a high interest in weed impact data and a pasture weed impact calculator – 98% of randomly surveyed graziers reported they would be motivated to control weeds if a significant impact to grazing operations was shown. The benefits were also highlighted via the literature review, survey and focus groups.

Our recommendations are to progress from a scoping study to a full project which involves three phases – data collection, development, and roll-out and extension of a pasture weed impact calculator for southern Australia. The pasture weed impact calculator would be a motivational tool to increase weed management by graziers, including the more reluctant weed managers. The information on weed impacts would demonstrate to graziers the direct link between weeds in the paddock, at different % coverage levels, and the impact to their grazing operations.

Data collection

The collection of weed impact data would involve additional desktop research, field photography linked to measurements of weed cover, survey of advisor estimates and, because of the concern by advisors about accuracy of information, field trials on a limited number of species to validate advisor estimates.

Desktop research (literature, internet and discussions with agronomists) will be required to analyse in more depth existing information on pasture weed impact to determine if generalised relationships exist for certain weed types, for example, weeds that are unpalatable and likely to have a direct linear relationship to loss in pasture production, such as serrated tussock.

We also recommend that a photographic library of important weed species at different stages of growth be collated and linked to measured percentages of weed coverage in pasture systems. These photographs will form the reference base for grazier assessment of weed infestation levels in weed impact calculations. This photographic reference library will also be used by advisors to estimate yield reductions from pasture weeds in their regions. While not all of these data will be supported by empirical information, multiple estimates can be obtained to give greater confidence levels. In this way a large number of weed species and regions can be incorporated in the initial launch of the pasture weed impact calculator.

In addition, we recommend field sites be set up in one representative region to monitor weed impact on pasture production for a minimum of three contrasting weed species, to validate estimates provided by advisors and so develop a proof of concept.

Development

The next phase would involve the development of hard copy and internet based versions of a pasture weed impact calculator to be able to be used by graziers and advisors. This would include compiling and synthesising all the information obtained through the data collection phase in a format guided by the results of this scoping study and MLA input. An electronic pasture weed impact calculator which mirrors the hard copy material should be developed and be hosted on the MLA web site.

Roll-out and extension

To maximise the compelling case for control, producers need to understand visual estimates of weed coverage and the direct relationship between % weed coverage of a weed species and

effect on pasture production and stocking rates. Workshops are suggested as the best means to extent this new innovation in weed impact assessment and control to supplement written and web based communications. These workshops would ideally be aimed at advisors who would then extend this tool through their regular advisory and extension activities.

We would be pleased to provide a proposal based on these recommendations, or any combination, in which MLA advises an interest.

Contents

1 Background

While there are generalised economic figures that show the enormous overall cost of weeds to the grazing industry and the relative lack of weed control efforts compared with the cropping industry (Sinden et al. 2004), information is lacking on the specific costs/benefits of individual species or functional weed groups at an individual farm or paddock level, that might drive adoption of weed control by individual graziers. A grazier who walks out into a paddock with an infestation of a particular weed species at a particular density is unable to reliably state what impact that weed has on potential production of their pasture and livestock operation in physical or financial terms, and whether control of the weed will increase or decrease profitability, given the cost of control. Other impediments to adoption exist, as shown by recent MLA funded research at the University of New England (UNE) (van der Meulen et al. 2007), but information on weed impact at the farm and paddock level in a format that can be readily accessed and used by graziers and industry advisors is the starting point in better decision making and improving adoption of weed control in the Australian grazing industries.

The United States Department of Agriculture (USDA) and Montana State University have recently developed an Invasive Weed Calculator that ranchers or advisors can access via the web and, having collected and entered some basic weed monitoring information from their paddocks, can have calculated for them on the spot the likely livestock production losses they are suffering because of the impact of the weed on pasture biomass production. The two weeds the calculator works for in the US are spotted knapweed (*Centaurea maculosa*) and leafy spurge (*Euphorbia esula*).

This short 5 month study scopes the outline, needs and format of a weed impact tool that could be used for temperate pastures in Australia.

2 Project Objectives

The objectives of this project were as follows:

- Scope the outline, need and format (and content) of a pasture weed impact calculator for use by graziers and their advisors in temperate southern Australian grazing systems, to underpin a compelling case for control.
- Review the literature and web on pasture weed impact data both in Australia and overseas that can be used at a farm and paddock level, and the existence of any other impact tools, and data around motivations and barriers to weed control.
- Conduct 40 red meat producer and 15 weed advisor interviews across southern high rainfall and cereal zones covering temperate and Mediterranean regions to test the potential demand, format (including content) and benefits of such a weed impact tool.
- Conduct 2 focus groups after the interview stage, to gain consensus on the format of the calculator, on number of weeds to be included and regions to be covered.
- Analyse US invasive weed calculator through discussions with the researchers and developers to assess its use and effectiveness, as well as the rationale behind its development in its current format.

3 Methodology

3.1 Literature and web review

A broad review of literature covering scientific journals, technical papers, books, publications from government agencies, conference proceedings and the internet was undertaken to locate pasture weed impact data at a farm and paddock level and the existence of other pasture weed impact tools. The literature review also covered the pest management decision making process by farmers, the process of adoption of new technologies and motivations and barriers to weed control.

3.2 Survey and focus groups

A cross-sectional telephone survey of graziers and weed advisors in southern Australia was conducted. Quota sampling methods were used to enable coverage of participants from several different segments – seven geographic segments, two agricultural zones and two climatic zones, as shown in Table 1. The survey questionnaire (see Appendices 9.2 – 9.3) was designed with input from graziers, weed advisors and University of New England staff. Pilot studies of the survey were undertaken to test for any ambiguous questions, and assist fine tune the questionnaire wording and ordering of questions. Human research ethics approval was granted for this survey and focus groups by the University of New England Human Research Ethics Committee (approval #HE11/053) on 25 March 2011.

The locations chosen for potential participants were selected to ensure coverage of the target segmentation. Potential participants of the grazier's survey were identified from YellowPages® online, using a search criterion of "grazier", and advisors were identified from the internet. Weed advisor participants represented state government agronomists, local council weeds officers, state government weed/pest officers and consultant agronomists. A total of 40 grazier phone surveys and 16 weed advisor surveys were completed. All survey data were recorded on paper at the time of interview and entered into a Microsoft Access database at the completion of all surveys.

Table 1. Breakdown of segments of grazier and weed advisor survey participants.

Segment	Grazier participants	Advisor participants
Geographic regions	Northern New South Wales (n=10) Southern New South Wales (n=9) North-east Victoria (n=5) Central & Western Victoria (n=4) Tasmania (n=4) South Australia (n=4) Western Australia (n=4)	Northern New South Wales (n=4) Southern New South Wales (n=4) North-east Victoria (n=3) Central & Western Victoria (n=2) Tasmania (n=1) South Australia (n=1) Western Australia (n=1)
Agricultural regions	High rainfall zone (n=26) Cereal zone (n=14)	High rainfall zone (n=13) Cereal zone (n=3)
Climatic regions	Temperate (n=27) Mediterranean (n=13)	Temperate (n=11) Mediterranean (n=5)
Weed advisor's role		State government (n=9) Local council (n=3) Private agronomist (n=4)

Two separate focus groups were held at the University of New England, Armidale – one comprising of producers and the other of advisors. The producer focus group comprised sheep and cattle graziers from the Armidale area who, according to personal communications, proactively manage their pasture and weeds. The advisor focus group was comprised of state government district agronomists, a private agronomist, a council weed officer, a pasture researcher, and board member of the Namoi Catchment Management Authority/Chairperson of New England Weeds. The focus group participants were provided with the background and context of the project and summary results of the survey, and then discussions were held on the demand, benefit, features, format and future development of the concept of a pasture weed impact calculator. Participants also evaluated the online USDA invasive weed impact calculator.

4 Results and discussion

4.1 Literature and web review

4.1.1 Lack of pasture weed economic impact data

Pasture weed economic impact data are recognised as a research gap in Australia (Pannell 1988; Townsend and Sinden 1999; Vere et al. 2002). Economic analysis has been an important deficiency in weed science, particularly in relation to pasture weeds. Such information could be used to demonstrate the economic effect of a weed species and to encourage weed control (Vere et al. 1993). This apparent lack of economic research means that weed control may be based on incomplete information regarding the losses and costs arising from weeds, and the potential benefits from their control (Pannell 1988). The main purpose of economic assessments of pasture weeds is to assist in weed control planning (Vere et al. 1993). The available economic analysis of weed impact on pasture systems is considerably less than crop-weed scenarios. Weeds in pasture systems are more difficult to economically evaluate than crop weeds because the interactions between livestock and plant species are more complex than weed-crop interactions (Vere et al. 2002).

4.1.2 Adoption of innovations

The adoption of an innovation by farmers depends principally on whether farmers expect that the practice will help them to achieve their economic, social and environmental goals (Pannell et al. 2006). Kreuter et al. (2005) has described the experiences leading to a decision to adopt an innovation as – awareness, interest, acceptance, trial and adoption. Graziers often base their property management decisions on the condition of their livestock. It is therefore important to demonstrate to graziers the relationship between pasture condition (including impact of weeds on pasture) and productivity (Lawrence et al. 1994). Pasture assessment tools should be simple enough to be easily implemented by graziers, yet accurate enough to detect changing condition states. Furthermore such tools should use measures that are meaningful to graziers to enhance their acceptance and use (Lawrence et al. 1994).

4.1.3 Motivations and barriers to weed control

Grazier motivations to control weeds include health of livestock, value of livestock products, the invasive or competitive nature of weeds (van der Meulen et al. 2007), a need to protect forage/increase forage production, benefits for the next generation and increased real estate values (Kreuter et al. 2005). Barriers to weed control include an inability to identify particular

grass weeds, time and money constraints, difficult terrain, differences in perception of 'weeds' (van der Meulen et al. 2007), weed spread from neighbours, heterogeneity of the landscape, lack of effective control measures and lack of information (Aslan et al. 2009).

The need for pasture weed impact information is supported by the effect it can have on weed control barriers. The barriers to weed control which pasture weed impact data could break down are differences in perception of 'weeds', inability to identify particular grass species and heterogeneity of the landscape. If graziers were made aware of the actual effect on carrying capacity due to the presence of a particular weed species, at a certain % coverage, they can objectively assess whether not controlling the weed is the best outcome for their grazing operation. Impact data could also encourage producers to increase their skill at identifying and assessing particular grass species, e.g. if it is known that a 30% coverage of Coolatai grass in a paddock reduces pasture production by a certain percentage, then one is more likely to go and determine the weed status on the farm through correct identification. To help overcome the barrier of heterogeneity of the landscape, producers can assess their properties on a paddock by paddock basis using % weed coverage to determine impacts on smaller, more homogenous areas of the properties.

Weed impact data will also support weed control motivations. Demonstrating the impact on pasture production supports the motivation of needing to protect/increase forage, while showing the reductions in carrying capacities due to weeds supports the motivation of the value of livestock products. A pasture system with a higher level of pasture production, through the management of weeds, adds to the value of the land and supports a sustainable system for future generations. Therefore weed impact data also appeals to graziers motivated by land value and wanting to pass on their land to benefit the next generation.

4.1.4 Pest management decision making

Weed impact data at a farm or paddock level, will also underpin a compelling case for control via influences on a grazier's pest management decision making process. Having this information in the format of a hard copy or electronic calculator, is an additional resource which can influence a producer's perception of the pest problem, and according to the pest-control decision-making process (Figure 1), sharing this data with stakeholders could increase weed control activities. For example, if a particular producer views their patch of St John's wort or a certain grass weed as of no major concern to their grazing operations, having information about the actual effect of this weed on carrying capacity is likely to change their perception of the pest problem.

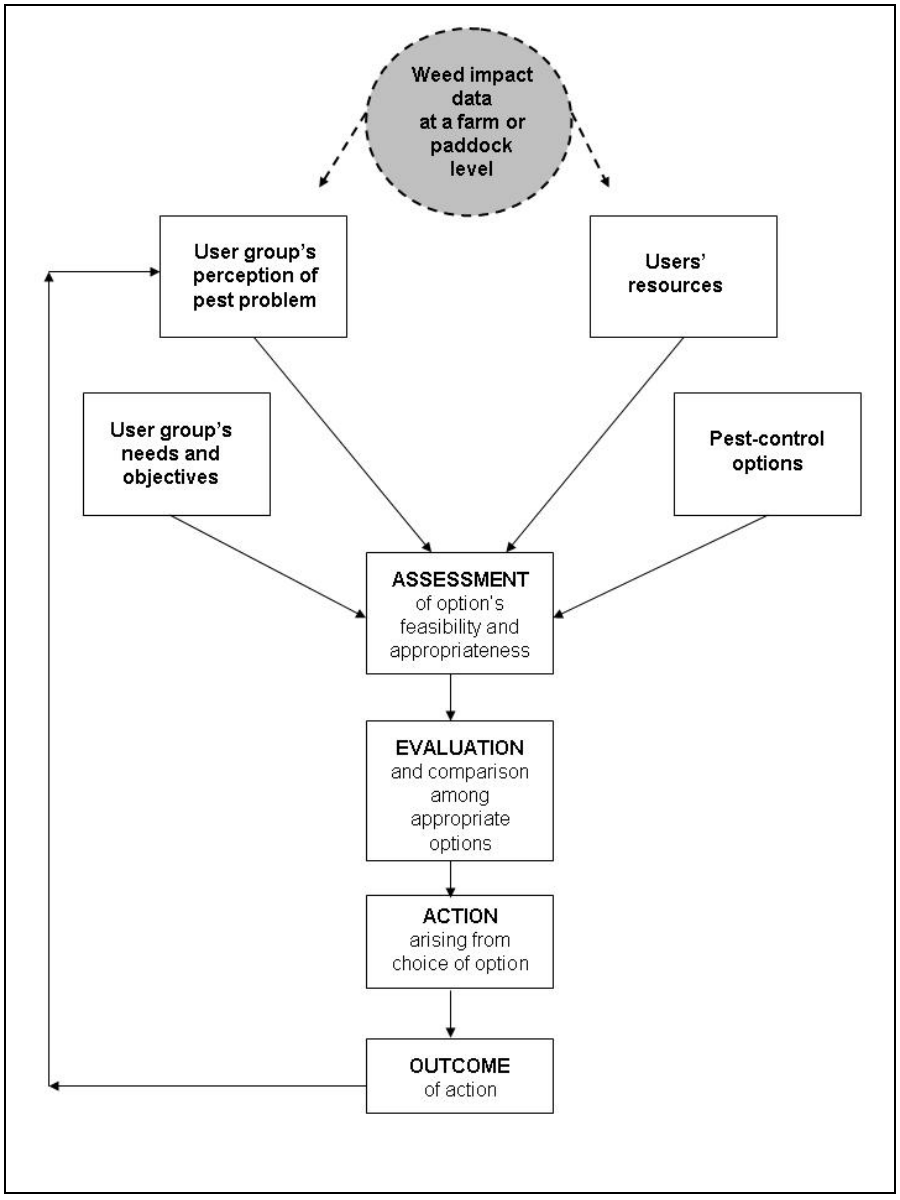

Figure 1. The pest-control decision-making process (after Reichelderfer and Bottrell 1985), showing how weed impact data at a farm or paddock level can influence this process. The dotted circle and arrows at the top of the figure have been added.

4.1.5 Existing pasture weed impact data

Economic impact of pasture weeds will encourage improved weed management by producers, but the lack of such information is recognised as being a major constraint to weed-control decision making (Vere et al. 2002). A summary of available pasture-weed impact data at a farm or paddock level, both in Australia and overseas is presented in Table 2.

Table 2. Weed species which currently have pasture impact data available.

Weed species	Details
Leafy spurge (*Euphorbia esula*)	Through trials in North Dakota (USA), a livestock carrying capacity function was developed by Leistritz et al. (1992) to determine the reduction in carrying capacity due to leafy spurge infestation. Leafy spurge infestation reduces livestock carrying capacity by reducing forage production due to competition. The carrying capacity = 100 – 1.25 x (% infestation of pasture covered by leafy spurge) (Leistritz et al. 1992). Rinella and Luschei (2007) also developed a model of leafy spurge impact for inclusion in the United States Department of Agriculture invasive weed impact calculator.
Serrated tussock (*Nassella trichotoma*)	Serrated tussock is listed as a Weed of National Significance (WONS) in Australia and is recognised as causing the greatest reductions in stocking rates of any pasture weed in Australia (Vere and Campbell 1984). A linear damage curve has been reported in New Zealand trials by Denne (1988) for serrated tussock in pasture, with a 50% ground cover of serrated tussock infestation equating to a 50% loss of pasture production.
Paterson's curse/ Salvation Jane (*Echium plantagineum*)	Although there are no data on reduction in pasture production or carrying capacity, slower growth rates and reduced total weights (c. 10%) in sheep grazing on pastures with 80% ground cover of Paterson's curse compared with a control have been reported at trials near Orange, New South Wales (Seaman et al. 1989).
Scotch thistle (*Cirsium vulgare*)	Although there are no data on reduction in pasture production, changes in sheep live weight gain have been reported from trials in New Zealand. Live weight gain (kg ha^{-1}) = 7.8 – 1.68x, where x = number of scotch thistles m^{-2} (Hartley 1983a). One scotch thistle plant per square meter has been reported to reduce sheep live-weight gain in the summer by over 20% (Hartley 1983a).
Californian thistle, Canada thistle, Perennial thistle, Creeping thistle (*Cirsium arvense*)	Pasture losses of up to 15% have been reported in Canada from two shoots of *C. arvense* per 0.91 m^2 (Hodgson 1968). Grekul and Bork (2004) reported Canada thistle densities of 20 shoots m^{-2} resulted in herbage yield reductions of 510 and 868 kg ha^{-1} pa for two sites in Canada.
Yellow starthistle, St Barnaby's thistle (*Centaurea solstitialis*)	In California, USA, a 25% ground cover of St Barnaby's thistle reduced forage production by 12.8% (Eagle et al. 2007).
Nodding thistle, musk thistle (*Carduus nutans*)	Thompson et al. (1987) reported that 1,000 nodding thistle plants ha^{-1} (equivalent to 1 per $10m^2$) in New Zealand reduced pasture dry matter by 8%. For every 1% ground cover of nodding thistle, it is reported to reduce the annual liveweight gain from sheep by 21 kg ha^{-1} - based on a simplified mathematical model of nodding thistle reproduction, growth and competition with grass (Moore et al. 1989). A single *Carduus* species thistle per 1.49 m^2 has been reported to reduce pasture

	yields by an average of 23% (Kates et al. 1972).
Variegated thistle (*Silybum marianum*)	Auld et al. (1979) developed a function to determine the reduction in pasture production due to *S. marianum* based on trials in Orange, Australia. The function incorporates the time of year (month), proportion of farm affected by variegated thistle and the density of the infestation.
Rushes (*Juncus* spp.)	Each 1% coverage of rushes (*Juncus* spp.) has been reported to reduce sheep carrying capacity by 0.35 sheep ha^{-1} in New Zealand (Hartley 1983b).
Spotted knapweed (*Centaurea maculosa*)	Spotted knapweed impact on carrying capacity and pasture production is available through the United States Department of Agriculture invasive weed impact calculator.
Giant buttercup (*Ranunculus acris*)	Bourdot et al. (2003) reported a loss in utilisable pasture dry matter of 3.581 t ha^{-1} pa for an average 26% ground cover of giant buttercup in trials in New Zealand.

Case studies of the costs and benefits of weed control for several species are included in the MLA/AWI 3D Weed Management publications. The weed species covered are African lovegrass, Chilean needle grass, Onopordum thistles, Paterson's curse, serrated tussock and silverleaf nightshade.

4.1.6 Pasture weed impact tools

There are several weed impact decision support tools available on the internet, however the majority of these are for crop-weed interactions. Furthermore, decision support systems for weed management have focused on herbicides and most have had a relatively short-term focus (Pannell et al. 2004). There is a limited number of pasture based weed decision management tools currently available. These are detailed below. A survey conducted in 2001 in the USA found 82% of weed science professionals surveyed believed that computer software and models can be beneficial in making weed management decisions (Wilkerson et al. 2002).

USDA invasive weed impact calculator

The United States Department of Agriculture (USDA) and Montana State University developed an online invasive weed impact calculator for leafy spurge (*Euphorbia esula*) and spotted knapweed (*Centaurea maculosa*). This online tool was launched four years ago and is available at http://199.133.173.229/WeedImpact/. The inclusion of leafy spurge and spotted knapweed is predominantly due to the very large ecological and economic importance both these weeds have in the United States, particularly to grazing, and the large amount of data available on these species. For example, leafy spurge was estimated to affect 485,600 ha in 1987 and has been reported to reduce livestock carrying capacity by as much as 75% (Leistritz et al. 1992). Users of this tool select the relevant species (currently limited to two species), and enter data on the densities of the weed in their paddocks measured using quadrats. The minimum requirement for input data is counts from 10 to 30 quadrats on the number of rosettes and measurements of stem heights of bolted plants. The model then outputs the production of weed biomass in pounds per acre, the percentage reduction in production of other species due to the weed presence, the improvement to pasture production if the weed is eliminated and the change in carrying capacity after effective weed control. These steps are summarised by Figure 2 which contains screen images of the pasture weed impact calculator.

Discussions were held with Dr Matthew Rinella, who was the lead developer of the USDA invasive weed impact calculator. In regards to the uptake of the computer model, the developer reported low levels of model use – around 300 over four years. With only two weeds currently built into the model, both of which are well known invasive plants of grazing land, there is a belief by the developer that if graziers weren't so aware of the impact that these weed species were having to their grazing operations then the calculator would be more widely used. Another comment regarding the low uptake was the requirement of users to undertake field work to collect data from 10 to 30 quadrats – measuring heights and rosettes. Our focus group producers also highlighted this as a major impediment if required for any calculator use. Furthermore, some users wanted to know about weed species spread – the future cost of not controlling the weed, which is ignored in this model. Enquiries were made as to any measured behavioural changes by producers as a result of this model, however no such data have been collected. The format of the model was largely driven by the logic that weed impact = impact per unit weed abundance x weed abundance. Based on this model, weed abundance data from the site of interest are needed to calculate weed impacts. No improvements, changes or additions are planned for this model at this stage although the developer believes the calculator can "over-intellectualise the weed situation".

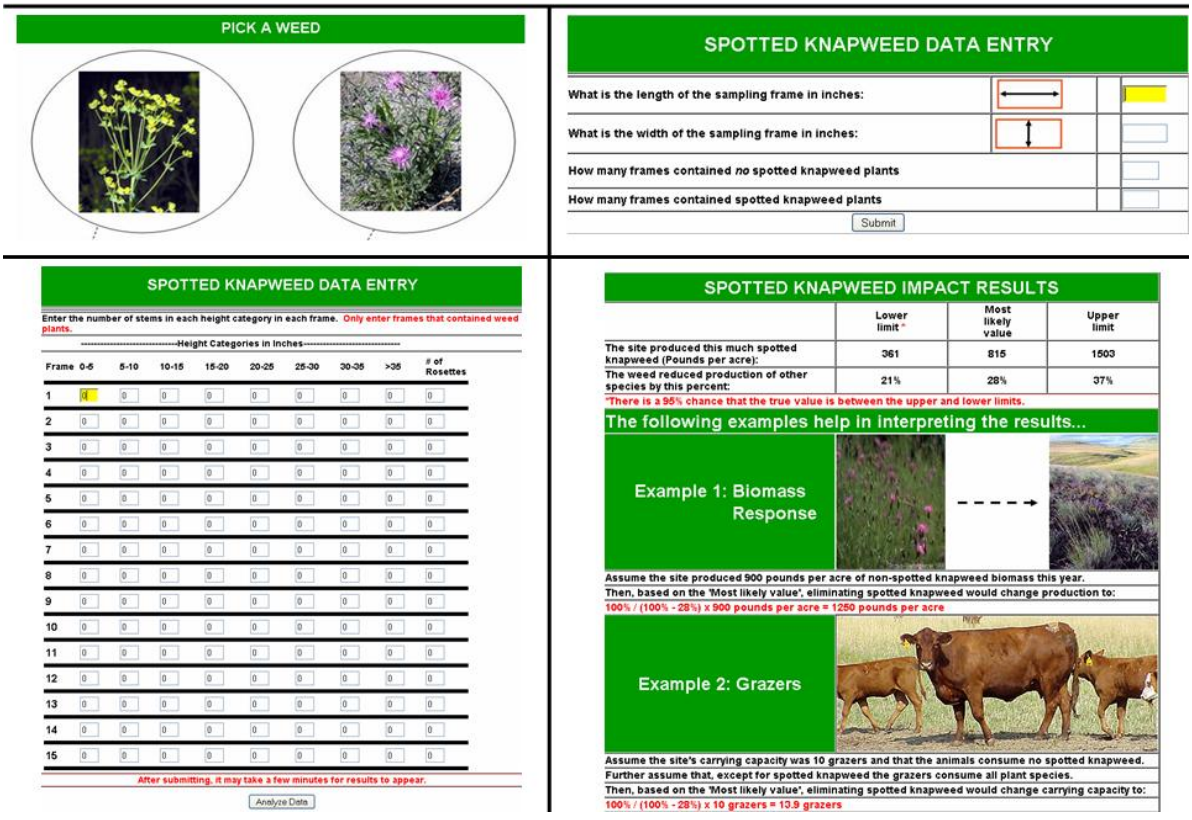

Figure 2. Screen images of the USDA Invasive Weed Impact Calculator.

Participants of the producer and advisor focus groups were given a demonstration of the USDA invasive weed impact calculator and their feedback was sought on its strengths and weaknesses.

A summary of feedback from the participants is presented in Table 3. While participants saw shortcomings of the USDA computer based tool, they nevertheless remained strongly supportive of the concept and had various suggestions of methods to better utilise such impact information, which we would plan to incorporate in the development of an Australian tool.

Table 3. Strengths and weaknesses of the USDA invasive weed impact calculator, as reported by focus group participants.

Strengths	Weaknesses
• Impact on stocking rate output is a helpful measure and could lead to weed control action. • Knowing there could be a large increase in pasture production if weeds are controlled is helpful information and could lead to increased control. • Output data could assist decisions on whether to buy/lease more land or improve current land to increase stocking rates.	• Time consuming to do all the field work / quadrat methodology. Extensive field work required by user would reduce the adoption of any such tool. • Variability of impact levels is a weakness. • No output data on the effect on animal live weight gain. • Model assumptions are fixed. For example, the model assumes that the weed provides no palatable biomass, the biomass production per acre of non-target weed species is fixed, and so are the stocking rate levels. • There is no means of putting information into the model on what pasture is on the farm/paddock at present. • No detailed identification information is supplied for the two species included in the model.

PESTMAN

'PESTMAN online weed and brush control advisor' was developed by the US government and university agencies for the grazing industry to allow on-demand, simultaneous selection of both the technically feasible treatment alternatives for weed control and the economic risks associated with brush and weed control investment decisions. PESTMAN was developed by combining two existing models, EXSEL and GAAT (Grazingland Alternative Analysis Tool), and making improvements to these earlier models. Included is a digital image database of plants to assist with weed identification and fact sheets on ecology and distribution of weed species. The EXSEL component requires minimal data input to accurately support mechanical and chemical brush and weed control decisions. There are numerous weed species included and it is relevant to various geographic regions. The user inputs the target weed species, stem diameter and height information and the application provides the most technically feasible treatment alternatives. In addition to information on specific chemical and mechanical treatment recommendations for the target weed species, output information also covers the level of target weed mortality, expected vegetation responses, for example, when to expect maximum production increases, how long they will last and when vegetation will return to pre-treatment levels without maintenance practices. The GAAT component provides an economic analysis tool

to test various scenarios, create and edit budgets, create and edit weed control measures and control programs, and create and edit livestock carrying capacity profiles. Although the model is live on the internet, it appears to still be undergoing development. The PESTMAN model is available at http://pestman.tamu.edu/#0.

Weedometer

The "Weedometer" was developed by Arlington Research Station, University of Wisconsin, and although it is not essentially a pasture weed impact tool, it is a pasture weed decision support tool. Weedometer provides comparative gannt charts on weed life cycle timing for several weed species, and identifies the timings of emergence and flowering for weed species based on their geographic region. The tool is available at http://weedecology.wisc.edu/. This program is particularly relevant for the development of growth curve schematics for pasture weeds in Australia which is the subject of a separate UNE funding application to MLA currently under consideration.

Resistance and integrated management model

The University of Western Australia released a Resistance and Integrated Management (RIM) bioeconomic model for management of annual ryegrass (*Lolium rigidum*) in 1999 and issued a new version in 2004. This Microsoft Excel model is sold for $55.00 on a CD-ROM. Although designed for cropping enterprises, there are provisions for grazing rotations within the model. It is a tool for testing the biological and economic performance of integrated weed management systems for herbicide-resistant annual ryegrass. This model requires a large amount of input from the user. The tool allows farmers to examine different control strategies, or combinations of strategies, and extend results beyond a single year, for example, the 1999 version of RIM allows for 20 years.

Lantana decision support tool

A Lantana Decision Support tool has been developed by Queensland Primary Industries and Fisheries and presented as a CD-ROM with manual/brochure. The tool assists land managers integrate efficient and cost effective control techniques for lantana (*Lantana camara*). Land managers input details regarding access to the infestation, the density and size of infestation and the output details the time, costs and efficacy of controls (Stock et al. 2008).

Conclusions

The web and literature review on pasture weed impact models showed that there are no models for the major pasture weeds of southern Australia. The USDA Invasive Weed Impact Calculator reports impact data on two weeds for American rangelands, PESTMAN is still under development and is based on American conditions, Weedometer does not provide impact data, the Australian RIM model is a complex model to examine long term effects of weeds and weed control in cropping and pasture rotations and the Lantana Decision Support Tool is restricted to one shrub species.

4.2 Survey and focus groups

There was a high survey participation rate (85%), with only 10 declines in survey consent during the collection of 56 completed surveys (40 graziers and 16 advisors). Grazier and advisor participants were from regions within southern Australia, comprising both high rainfall and cereal

zones and temperate and Mediterranean climatic regions. Survey participant farming production covered sheep, cattle, cattle/goats, crops/livestock, and crop and grazing rotations. Weed advisor participants included state government district agronomists, local council weeds officers, and private agronomists. Grazier participants were asked if they classify themselves as early adopters of technology relevant to grazing operations. Those identifying as early adopters and others have been separated in the results tables.

The median farm size was in the 500 to 2,000 ha range with an average of 38% improved pastures (defined as species sown) and median weed coverage of pasture was in the 10 to 20% range. Median age of graziers surveyed was 40 to 50 years and for weed advisors, 30 to 40 years. In regards to computer use, 85% of grazier respondents use a computer and 82% use the internet, compared with 100% of the advisor participants. Some graziers reported that weed control is a priority on their farms at present, others reported that after a period of drought and then significant rain, weeds are more problematic, and one grazier mentioned that after recent flooding there are new weed species on their property.

4.2.1 Assessing the demand and benefits of a pasture weed impact calculator

Survey questions on demand for a pasture weed impact calculator confirmed the perceived difficultly for graziers and advisors in estimating costs of a weed species on production (Table 4), how impact data would assist in weed control decision making (Table 5) and the likelihood of stakeholders using such a tool (Table 6). To assess the benefits of a pasture weed impact calculator graziers were asked if they would be motivated to control a weed if it was known to be causing significant economic impact. Advisors were asked if they believed graziers would be motivated to control and also what other benefits the tool could bring (Table 7). The producer and advisor participants at the focus group sessions also provided their feedback on the demand and benefits of a pasture weed impact calculator.

Difficulty in estimating costs to grazing of particular weed species

When survey participants were asked about the current difficulty in estimating costs to grazing operations of a particular weed species, the majority of respondents (92% of graziers and 100% of advisors) agreed that currently it is difficult to estimate. There were small differences in the grazier responses between the early adopters and non-early adopters – 12% of early adopters stated that it is currently not very difficult to estimate costs to production compared with only 4% of non-early adopters. Furthermore, a higher percentage of early adopters rated the difficulty level of estimating costs as very difficult (47%) over quite difficult (41%), whereas the non-early adopters had a greater percentage stating quite difficult (61%) over very difficult (35%) (Table 4).

Table 4. Survey results on the current difficulty of estimating the costs to a grazing operation of a particular weed species.

	Graziers			**Advisors**
	All (n=40)	Early adopters (n=17)	Others (n=23)	(n=16)
Not very difficult	8%	12%	4%	0%
Quite difficult	52%	41%	61%	69%
Very difficult	40%	47%	35%	31%

Weed control decision making with more accurate impact data

Survey participants were asked if having accurate information on the costs to grazing operations of each weed species would make for easier weed control decisions. All advisors and 93% of graziers believed that accurate information on the costs to grazing operations of weed species would make weed control decisions easier. The early adopter group had the highest percentage of respondents suggesting that accurate information on weed impacts would not make a difference in their weed control decisions (12%). This result is mainly due to the fact that many of them stated that they are already proactive with weed control and they aim to keep weed coverage to a minimum (Table 5).

Table 5. Survey results on whether weed control decisions would be easier with accurate information on weed impact costs.

	Graziers			**Advisors**
	All (n=40)	Early adopters (n=17)	Others (n=23)	(n=16)
Much easier	68%	59%	74%	88%
A little easier	25%	29%	22%	12%
No difference	7%	12%	4%	0%

Demand for a computer model

Survey participants were asked if they would use a computer program that calculated the costs to grazing operations of a particular weed species. Although 75% of grazier respondents said they would use a computer model that calculated the costs of weeds to grazing, the 20% reporting they were unsure of their use was mainly due to a lack of computer literacy and many stated a preference for paper based summaries of pasture weed impact data. This latter point was reiterated in the focus groups. There was a higher proportion of non-early adopters reporting they would use the tool compared with early adopters (78% and 71% respectively) (Table 6). The one 'unsure/maybe' response from a weed advisor was due to a need for them to be confident of the accuracy of the information in the model.

Table 6. Survey results on whether graziers and advisors would use a computer tool to determine weed impacts on operations.

	Graziers			**Advisors**
	All (n=40)	Early adopters (n=17)	Others (n=23)	(n=16)
Yes	75%	71%	78%	94%
No	5%	6%	4%	0%
Unsure / maybe	20%	23%	18%	6%

Weed advisors were asked to estimate the uptake by graziers of a pasture weed impact calculator. A summary of the main points are as follows.

- If promoted well, a large percentage of graziers would use it.
- If available in both electronic (e.g. internet) and hard copy, there would be greater uptake.
- One district agronomist believed graziers who are computer savvy would have a high uptake of the tool.
- A representative from Tasmania believed that with 6,000 members of the Tasmanian Farmers and Graziers Association, there is opportunity to promote and support the tool through the Association, thereby increasing its use by farmers.
- A South Australian government representative believed that if a pasture weed impact tool was developed and promoted through South Australia's eight regional Natural Resource Management (NRM) Boards that there would be a high uptake by graziers.
- Good promotion and an easy to use system will increase uptake.

Motivation to control

The survey participants were asked if they would be motivated to control a weed species if it was shown to be causing significant economic impact to their grazing operations. All non-early adopters reported they would be motivated to control a particular weed species if it was demonstrated to be causing significant economic impact to their grazing operation. Of the advisors 88% believed such information would motivate graziers to control a weed species. The unsure/maybe responses from the advisors (12%) was due to the belief that not all graziers are motivated on an economic level (Table 7).

Table 7. Survey results on whether graziers would be motivated to control weeds if it was demonstrated to cause significant economic impact to operations.

	Graziers			**Advisors**
	All (n=40)	Early adopters (n=17)	Others (n=23)	(n=16)
Yes	98%	94%	100%	88%
No	0%	0%	0%	0%
Unsure / maybe	2%	6%	0%	12%

Other benefits

Weed advisors were asked what other benefits they believed a pasture weed impact calculator could bring to graziers. A summary of the main points raised by survey participants are shown below.

- An increase in grazier motivation to control weeds.
- Assist with a change of attitude within some graziers with regards to weed management.
- Improvements to livestock health and the environment.
- Would complement well with the EverGraze pasture improvement calculator and Pasture Picker software.
- Assist in weed control decision making for often time poor primary producers.
- Provide a better utilisation of moisture and nutrients for pasture through an increased level of weed control.
- Graziers will be able to look at grazing value of pastures more objectively.
- Encourage early control of weeds in pastures.

- Demonstrating the costs of not controlling particular weed species would be very useful in increasing weed control rates.
- Better management of pastures.
- Increased carrying capacities on grazing land.

Focus group comments on demands and benefits

The participants of the producer focus group also believed that there was demand for weed impact data at a farm or paddock level, and that such data would be very useful, particularly if comparisons between weeds were possible. Participants also believed that if graziers were made aware of the impact of weeds to their operations that this could motivate weed control measures. The benefits reported by the producers were assistance with prioritising weeds, the possibility of unmotivated weed controllers changing their behaviour if impacts to their operations were demonstrated and the ability to better understand the impact of grass weeds which are more difficult to control and identify and which may have some grazing value at certain times. It was reported that smaller acreage farmers who are not earning significant farm income may not be motivated to change weed control practices, unless driven by non-economic incentives. The advisor focus group suggested that data on non-noxious weeds (i.e. those not generally declared under legislation) would be particularly helpful as well as noxious weeds dealt with at a management level (e.g. Class 4 weeds in NSW), and weeds which are spreading and/or have large potential impacts.

4.2.2 Assessing the format and content of a pasture weed impact calculator

Possible features

The preferred format and content of a pasture weed impact calculator was assessed during the survey by reading a list of different possible features to the survey participants. Reponses to the question were on a scale where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree. The median score for all features included was 4 (agree) or 5 (strongly agree). There were no disagree or strongly disagree results recorded from any survey participant for any of the features. Summary results are presented in Table 8. Feedback on the format and content of a pasture weed impact calculator was also obtained at the two focus group sessions.

Table 8. The median scores for features and content to be included in a pasture weed impact calculator.

Feature / content	Graziers	Advisors
Able to quantify the impact of a weed species on pasture production	4	4
Able to quantify the impact of a weed species on stocking rates	4	4
Able to quantify the impact of a weed species on feed availability	4	4
Able to quantify the impact of a weed species on the environment	4	4
Able to quantify the impact of a weed species on livestock health	4	4
Able to quantify my loss in income	4	4
Able to provide a benefit:cost analysis of weed control	5	5
Able to explain how the weed spreads	4	4
It must be relevant to my area or region	5	5
It includes weed identification tips	4	4
It explains how to best control the weed	4	4
It is free to use	5	4
It is available on the internet	4	5
It is available as an application you can download onto your computer	4	4
It is available as a paper based version	4	4

Two of the most strongly agreed features were the same for the graziers and advisors – being relevance to their area or region and ability to provide a benefit:cost analysis of weed control. Grazier and advisor survey participants were asked if there were any other features that they believe should be included in such a tool. A summary of the responses are below.

- Simple to use
- Accuracy of information
- Impact on persistence of perennial pasture
- Impacts to production per head (shown as gross margin per DSE)
- Caters for rotational cropping situations as well as 100% grazing
- Longer term impacts would be beneficial, i.e. incorporating seed banks

Weed species to include

To further explore the content of any pasture weed impact calculator, survey participants were asked to name their top three problem weeds on which they would like impact data. A list of weeds mentioned and the total number of responses for each weed is presented in Table 9 (combining grazier and weed advisor results), and a breakdown by geographic region and split between graziers and advisors is shown in Table 10. Problem weeds comparing the graziers and advisors responses are presented in Table 11. Thistles were the highest reported, although the majority of survey participants did not mention a particular thistle species.

Table 9. Collated responses of the main weeds survey participants would like included in a pasture weed impact calculator.

Common name	Scientific name	Total responses
Thistles	*Carduus* spp., *Cirsium* spp., *Onopordum* spp., *Silybum* spp. and *Centaurea* spp.	20
Bathurst burr	*Xanthium spinosum*	17
Paterson's curse / Salvation Jane	*Echium plantagineum*	16
St John's wort	*Hypericum perforatum*	9
Serrated tussock	*Nassella trichotoma*	9
Capeweed	*Arctotheca calendula*	9
Chilean needle grass	*Nassella neesiana*	7
Barley grass	*Hordeum leporinum*	6
Fleabane	*Conyza* spp.	6
Ragwort	*Senecio jacobaea*	6
Gorse	*Ulex europaeus*	5
Horehound	*Marrubium vulgare*	5
Blackberry	*Rubus fruticosus*	5
Coolatai grass	*Hyparrhenia hirta*	4
Blue heliotrope	*Heliotropium amplexicaule*	4
African love grass	*Eragrostis curvula*	4
Silvergrass	*Vulpia* spp.	3
Onion grass	*Romulea rosea*	3
Ink weed	*Phytolacca octandra*	2
Paddy melon	*Cucumis myriocarpus*	2
Silverleaf nightshade	*Solanum elaeagnifolium*	2
Wild radish	*Raphanus raphanistrum*	2
Cape tulip	*Homeria* spp.	1
Fireweed	*Senecio madagascariensis*	1
Giant Parramatta grass	*Sporobolus fertilis*	1
Lippia	*Phyla canescens*	1
Narrowleaf cotton bush	*Gomphocarpus fruticosus*	1
Noogoora burr	*Xanthium pungens*	1
Mimosa bush	*Acacia farnesiana*	1
Galvanised burr	*Sclerolaena birchii*	1
Cobbler's peg	*Bidens pilosa*	1

Table 10. The main weeds survey participants would like included in a pasture weed impact calculator split by geographic region and between graziers and advisors.

Geographic region	Top three most reported weeds	
	Graziers	**Advisors**
Northern NSW	1. Thistles 2. Chilean needle grass 3. St John's wort 3. Bathurst burr	1. Serrated tussock 2. Chilean needle grass 3. St John's wort
Southern NSW	1. Paterson's curse 2. Serrated tussock 3. St John's wort 3. Fleabane 3. Thistles	1. Thistles 2. Serrated tussock 3. Paterson's curse
North-east VIC	1. Bathurst burr 2. Ink weed 3. Ragwort	1. Capeweed 2. Paterson's curse 3. Bathurst burr
Central and Western VIC	1. Paterson's curse 2. Bathurst burr 3. Thistles 3. Blue heliotrope	1. Barley grass 2. Onion grass 3. Silvergrass
TAS	1. Gorse 2. Thistles 3. Ragwort 3. Horehound	1. Gorse 2. Ragwort 3. Thistles
SA	1. Paterson's curse 2. Chilean needle grass 3. Bathurst burr	1. Silverleaf nightshade 2. Paterson's curse 3. Bathurst burr
WA	1. Wild radish 2. Bathurst burr 3. Capeweed 3. Paddy melon	1. Capeweed 2. Barley grass 3. Wild radish

Table 11. The main weeds survey participants would like included in a pasture weed impact calculator split by graziers and advisors, ranked from most reported to least.

Grazier responses	Advisor responses
1. Bathurst burr 1. Thistles	1. Barley grass 1. Capeweed 1. Paterson's curse 1. Thistles
2. Paterson's curse	2. Serrated tussock
3. St John's wort	3. Bathurst burr 3. Chilean needle grass 3. Onion grass 3. Silvergrass 3. St John's wort 3. Fleabane
4. Blackberry 4. Chilean needle grass 4. Horehound 4. Ragwort 4. Serrated tussock	4. Coolatai grass 4. Fireweed 4. Galvanised burr 4. Giant Parramatta grass 4. Gorse 4. Mimosa bush 4. Ragwort 4. Silverleaf nightshade 4. Wild radish
5. African love grass 5. Blue heliotrope 5. Capeweed 5. Gorse 5. Fleabane	
6. Coolatai grass	
7. Ink weed 7. Paddy melon	
8. Barley grass 8. Cape tulip 8. Cobbler's peg 8. Lippia 8. Narrowleaf cotton bush 8. Noogoora burr 8. Onion grass 8. Silvergrass 8. Silverleaf nightshade 8. Spear grass 8. Wild radish	

Focus group input on format and content

Focus group participants were asked to comment on the number of weed species for which impact data should be collected, by what means priority weeds and regions should be determined for inclusion and the format and content of a pasture weed impact calculator. The results are presented in Table 12.

Table 12. Focus group comments on the format and content of a pasture weed impact calculator for southern Australia.

Feature	Focus group comments
Weed species and how many weeds to include	The focus group participants indicated that having several species is important to allow comparisons and prioritisation of species and encourage uptake. Suggestions for the method of determining weed species to be covered included: • Grasses (e.g. Chilean needle grass, African lovegrass) which are relatively new and producers are not sure of their impact to pasture production. • Species which are spreading and which can be controlled effectively (e.g. St John's wort). • Weed species which are easiest to gather impact data on as first priority. • Weed species which have a high risk of potential spread and for which the pasture production/live weight effect on stock is unknown. • Select a weed species from different functional groups e.g. annual grass, perennial grass, annual broadleaf and perennial broadleaf initially. • Include weed species on which graziers/advisors have differing views on their 'weed' status (e.g. *Vulpia* spp.).
Geographic regions, flexibility of data and use of advisor estimates of weed impact.	The focus groups generally agreed that there would be large variation in weed impact results between regions and therefore the data needed to be regionally specific. The possible use of estimates for different regions rather than empirical data raised concerns amongst the focus group participants that the acceptance and uptake of the pasture weed impact calculator would be reduced as the accuracy was reduced. When the weed advisor focus group participants were asked if they could/would offer estimates on some weed impacts to pastures, they thought that this could be possible, but they were concerned about accuracy of information.
Input variable for calculator	Focus group participants unanimously agreed that the input for any pasture weed impact calculator should be % weed coverage. This measure will avoid the need for detailed field work by producers (e.g. counting several quadrats) and therefore encourage higher uptake. Producer focus group participants agreed that they would not perform detailed field work to collect input data and the advisor participants also agreed and suggested that if a large effort is required by graziers, they will either not use the system or ask their advisors to perform any field work required. Producer focus group participants also recommended having representative photographs showing different percentage weed cover and that it would be helpful if photographs taken by farmers could be used to estimate % weed coverage. The latter could also provide a record of changes in vegetation composition over time.

Output measure of impact calculator	The preferred output measure of weed impact reported by the focus group participants was the effect on livestock production (meat/wool) in kg ha^{-1}. Producer focus group participants did support the output measures of impact to pasture production and stocking rates during the USDA invasive weed impact calculator demonstration.
Other features to include	The inclusion of weed identification as content in any program or material developed was strongly supported in the survey and focus groups. The producer focus group participants reported a demand for the weed images to cover all life stages of the species, to allow more accurate and timely identification.

5 Success in achieving objectives

All project objectives have been fully achieved. These are summarised in Table 13.

Table 13. Summary of project objectives and success in achieving objectives.

Project objective	Success in achieving objective
To scope the outline, need and format (and content) of a Pasture Weed Impact Calculator for use by graziers and their advisors in temperate southern Australian grazing systems, to underpin a compelling case for control.	The need, format (including content) of a pasture weed impact calculator has been outlined in this final report.
Literature and web review on pasture weed impact data both in Australia and overseas that can be used at a farm and paddock level, and the existence of any other impact tools, and data around motivations and barriers to weed control.	The literature and web review has been completed and reported in the preliminary report (milestone #2) and contained in this final report with additions.
Have conducted 40 red meat producer and 15 weed advisor interviews across southern high rainfall and cereal zones covering temperate and Mediterranean regions to test the potential demand, format (including content) and benefits of such a weed impact tool.	The survey requirements for this project have been completed and the results were reported in the preliminary report (milestone #2) and contained in this Final report.
Have conducted two focus groups after the interview stage, to gain consensus on the format of the calculator on number of weeds to be included and regions to be covered.	Two focus groups were organised and held in May 2011 at the University of New England. One focus group was with producers and the other was with weed advisors (including government and private agronomists, a council weed officer, and board member of the Namoi Catchment Management Authority and Chair of New England Weeds Authority). Outcomes of the focus groups are included in section 4.2.
Analysed US Invasive Weed Calculator through discussions with the researchers and developers to assess its use and effectiveness, as well as the rationale behind its development in its current format.	Discussions with the developers of the USDA invasive weed calculator have been completed. Also an evaluation of the strengths and weaknesses of the model by the focus group participants is reported (section 4.1.6).

6 Impact on meat and livestock industry – Now and in five years time

If this project is progressed beyond a scoping study, the outcomes will assist graziers make more informed decisions on weed management and, if significant production losses are demonstrated through weed impact data at a farm/paddock level, will provide a compelling case for control, moving otherwise disinterested landholders to increase the feed supply, reduce production loss risks, stop the spread of invasive weeds, and increase their monitoring and assessment of pastures. With graziers made more aware of the impact of weed presence on their production, this will lead to improved weed control planning and motivate weed control compliance. These changes will lead to improved outcomes for industry and the environment – with increases in pasture production (through a reduction of weeds), improvements to livestock health and a reduction of weed spread.

7 Conclusions and recommendations

Strong demand for pasture-weed impact data at a farm or paddock level was clearly demonstrated through the literature review, telephone survey of graziers and their advisors and focus groups. The literature review showed that such data are limited, albeit important for weed control decision making and grazier motivation to control weeds. The survey demonstrated a high interest in weed impact data and a pasture weed impact calculator – 98% of randomly surveyed graziers reported they would be motivated to control weeds if a significant impact to grazing operations was shown. The benefits were also highlighted via the literature review, survey and focus groups.

Our recommendations are to progress from a scoping study to a full project which involves three phases – data collection, development, and roll-out and extension of a pasture weed impact calculator for southern Australia. The pasture weed impact calculator would be a motivational tool to increase weed management by graziers, including the more reluctant weed managers. The information on weed impacts would demonstrate to graziers the direct link between weeds in the paddock, at different % coverage levels, and the impact to their grazing operations.

Data collection

The collection of weed impact data would involve additional desktop research, field photography linked to measurements of weed cover, survey of advisor estimates and, because of the concern by advisors about accuracy of information, field trials on a limited number of species to validate advisor estimates.

Desktop research (literature, internet and discussions with agronomists) will be required to analyse in more depth existing information on pasture weed impact to determine if generalised relationships exist for certain weed types, for example, weeds that are unpalatable and likely to have a direct linear relationship to loss in pasture production, such as serrated tussock.

We also recommend that a photographic library of important weed species at different stages of growth be collated and linked to measured percentages of weed coverage in pasture systems. These photographs will form the reference base for grazier assessment of weed infestation levels in weed impact calculations. This photographic reference library will also be used by advisors to estimate yield reductions from pasture weeds in their regions. While not all of these

data will be supported by empirical information, multiple estimates can be obtained to give greater confidence levels. In this way a large number of weed species and regions can be incorporated in the initial launch of the pasture weed impact calculator.

In addition, we recommend field sites be set up in one representative region to monitor weed impact on pasture production for a minimum of three contrasting weed species, to validate estimates provided by advisors and so develop a proof of concept.

Development

The next phase would involve the development of hard copy and internet based versions of a pasture weed impact calculator to be able to be used by graziers and advisors. This would include compiling and synthesising all the information obtained through the data collection phase in a format guided by the results of this scoping study and MLA input. An electronic pasture weed impact calculator which mirrors the hard copy material should be developed and be hosted on the MLA web site.

Roll-out and extension

To maximise the compelling case for control, producers need to understand visual estimates of weed coverage and the direct relationship between % weed coverage of a weed species and effect on pasture production and stocking rates. Workshops are suggested as the best means to extend this new innovation in weed impact assessment and control to supplement written and web based communications. These workshops would ideally be aimed at advisors who would then extend this tool through their regular advisory and extension activities.

We would be pleased to provide a proposal based on these recommendations, or any combination, in which MLA advises an interest.

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9 Appendices

9.1 Survey participant information sheet

Appendix 9.1

Scoping study:
Development of a pasture weed impact calculator

une University of New England

mla MEAT & LIVESTOCK AUSTRALIA

Your invitation to participate

Graziers and weed advisors who are involved in working with graziers to manage weeds, from southern Australia are invited to participate in a survey designed to assess the demand, features and benefits of a pasture weed impact calculator. Participation is voluntary and the participant is free to withdraw consent and to discontinue participation in the activity at any time without prejudice.

Background

The cost of weeds to Australia's grazing industries has been estimated at $1.9 billion per year. Although there is a growing range of resources to assist graziers with weed identification and management options, there is a lack of information on the economic impact of weeds on pastures at the farm or paddock level. When a grazier is faced with a weed problem, they do not have sufficient information on the impact it has on livestock production (for example stocking rates, feed availability, pasture production) to make sound decisions about whether to control the weed or not. This project aims to determine the demand, features, content and benefits of a pasture weed impact calculator for southern Australia that assists graziers and their advisors to make those decisions.

This project is funded by Meat and Livestock Australia Limited (MLA) and is being carried out by the Agronomy and Soil Science Department at the University of New England (UNE), Armidale, NSW.

Protection of your privacy

All survey participants remain anonymous, whether undertaking the survey through the online version or over the telephone. There will be no identifying information recorded, only the broad geographic region from which the information came is recorded. Only the researchers involved in the study will have access to the survey data and a summary of the survey findings will be communicated to MLA. The information will be kept in secure storage at the Agronomy and Soil Science Department (UNE) and all data will be securely disposed of after 5 years.

Contact details

If you would like to know more about the project, or receive a summary of the project findings, please contact one of the project staff below.

Todd Green, Agronomy and Soil Science (UNE)
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Brian Sindel, Agronomy and Soil Science (UNE)
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(02) 6773 2962 Paul.Kristiansen@une.edu.au

This project has been approved by the Human Research Ethics Committee of the University of New England (Approval No. HE11/053, valid to 25/03/2012). Should you have any complaints concerning the manner in which this research is conducted, please contact the Research Ethics Officer at the following address:
Research Services
University of New England NSW 2351
Telephone: (02) 6773 3449
Facsimile: (02) 6773 3543 Email: ethics@une.edu.au

9.2 Grazier telephone survey

REF:

GRAZIERS PHONE SURVEY

Segmentation data (circle one option from each of the three segments)

Geographic region **NNSW** **SNSW** **NEVIC** **CEVIC** **TAS** **SA** **WA**

Agricultural region **HRZ** **CZ**

Climatic region **TMP** **MED**

Survey script

Good morning/afternoon/evening, my name is Todd Green and I am from the University of New England in Armidale, northern NSW, and we're conducting a brief survey for Meat and Livestock Australia about better weed control on grazing properties.

Is someone in your household involved in a commercial grazing enterprise?

Would it be possible to speak to a person in your household who has a major role in the running and decision-making on your property?

The University has been asked by Meat and Livestock Australia to assess the demand for a weed management decision tool which tells farmers what impact weeds are having on pasture and livestock production.

Would you be willing to answer some questions about your farm, weed management and your view on this decision tool?

The questions take about 5 minutes. Your answers are kept completely anonymous, that is we don't keep any information about who provided the answers.

If at the end of the interview you would like more information about the project, we can email or post that information to you.

Do you give consent to participate in this survey?

Consent obtained: ☐

[If Yes]: You are free at any stage to terminate the interview if you wish.
[If No]: Thank you (and terminate call)

Individual weed species may cause significant costs to grazing properties, for example on feed availability in the paddock, and on stocking rates.

Q 1. By observing weeds in the paddock, how difficult do you find it to estimate the costs to your grazing operations of a particular weed species?

☐ Not very difficult ☐ Quite difficult ☐ Very difficult

Q 1.	1	2	3

Q 2. Would it make it easier to make weed control decisions on your property, if you had more accurate information on the costs to your grazing operations of each weed species?

☐ Much easier ☐ A little easier ☐ No difference

Q 2.	1	2	3

Q 3. If a weed was causing significant economic impact to your grazing operation, would this motivate you to control the weed?

☐ Yes ☐ No ☐ Unsure / maybe

Q 3.	1	2	3

Q 4. Would you use a computer program that calculated the costs to your grazing operations of particular weed species, if all you had to do was enter the density of each weed into the program?

☐ Yes ☐ No ☐ Unsure / maybe

Q 4.	1	2	3

The following question requires a response on a scale of 1 to 5, where 1=strongly disagree, 2=disagree, 3=neutral, 4=agree and 5=strongly agree.

Q 5. If a new weed management tool was developed, providing impact data of weed invasions at a farm or paddock level, what features would you like it to have?

	1 strongly disagree	2 disagree	3 neutral	4 agree	5 strongly agree	
Able to quantify the impact of a weed species on pasture production						A
Able to quantify the impact of a weed species on stocking rates						B
Able to quantify the impact of a weed species on feed availability						C
Able to quantify the impact of a weed species on the environment						D
Able to quantify the impact of a weed species on livestock health						E
Able to quantify my loss in income						F
Able to provide a benefit:cost analysis of weed control						G
Able to explain how the weed spreads						H
It must be relevant to my area or region						I
It includes weed identification tips						J
It explains how to best control the weed						K
It is free to use						L
It is available on the internet						M
It is available as an application you can download onto your computer						N
It is available as a paper based version						O

Q 6. Are there any other features that you believe should be included in such a tool?

Details: _____

Q 7. What three weeds would you most like included if such a decision support tool was developed?

1. _____

2. _____

3. _____

Other response: _____

Q 8. Do you consider yourself an early adopter of new technologies relevant to grazing operations?

☐ Yes ☐ No, I prefer to wait ☐ Unsure /maybe

Q 8.	**1**	**2**	**3**

Q 9. What is the size of your farm?

<100 ha (<250 acres) 100-500 ha (<1250) 500-2000 ha (<5000) 2000-5000 ha (<12 500) 5000-10000 ha (<25 000) >10000 ha (>25 000)

Q 9.	**1**	**2**	**3**	**4**	**5**	**6**

Q 10. What do you produce on your farm?

cattle sheep crops crops and livestock other: _____

Q 10.	**1**	**2**	**3**	**4**	**5**	**6 (sheep/cattle)**

Q 11. Can you please estimate the percentage of improved pasture (that is, sown species) on your property?

%

Q 12. What would you estimate to be the average percentage groundcover of weeds in your pastures?

	<5%	5-10%	10-20%	20-30%	30-40%	40-50%	>50%
Q 12.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Q 13. Do you currently use any of the following to help you manage your grazing operations?

(a) A computer	**Y / N**	
(b) Software	**Y / N**	
(c) The internet	**Y / N**	

Q 14. In which age group do you fall?

<30 30-40 40-50 50-60 >60

Q 14.	1	2	3	4	5

Q 15. Do you have any questions or further comments about this concept of a pasture weed impact calculator?

_____

9.3 Advisor telephone survey

REF:

WEED ADVISORS PHONE SURVEY

Segmentation data (circle one option from each of the three segments)

Geographic region **NNSW** **SNSW** **NEVIC** **CEVIC** **TAS** **SA** **WA**

Agricultural region **HRZ** **CZ**

Climatic region **TMP** **MED**

Weed advisors role:

[ ] Government agronomist/weed advisor
[ ] Council weeds officer
[ ] Private agronomist
[ ] Other:

Good morning/afternoon/evening, my name is Todd Green and I am from the University of New England in Armidale, northern NSW, and we're conducting a brief survey for Meat and Livestock Australia about better weed control on grazing properties.

The University has been asked by Meat and Livestock Australia to assess the demand for a weed management decision tool which tells farmers what impact weeds are having on pasture and livestock production.

In addition to surveying graziers in southern Australia, we are also surveying weed advisors like yourself who play a critical role in this process. The questions take about 5 minutes. Your answers are kept completely anonymous, that is we don't keep any information about who provided the answers.

If at the end of the interview you would like more information about the project, we can email or post that information to you.

Would you be willing to answer some brief questions about your view on such a weed management decision tool?

Do you give consent to participate in this survey?

Consent obtained: ☐

[If Yes]: You are free at any stage to terminate the interview if you wish.
[If No]: Thank you (and terminate call)

Individual weed species may cause significant costs to grazing properties, for example on feed availability in the paddock, and on stocking rates.

Q 1. By observing weeds in the paddock, how difficult do you find it to estimate the costs to grazing operations of a particular weed species?

☐ Not very difficult ☐ Quite difficult ☐ Very difficult

Q 1.	1	2	3

Q 2. Would it make it easier to make weed control decisions on a grazing property, if you had more accurate information on the costs to grazing operations of each weed species?

☐ Much easier ☐ A little easier ☐ No difference

Q 2.	1	2	3

Q 3. If a weed was causing significant economic impact to a grazing operation, do you believe this would motivate graziers to control the weed?

☐ Yes ☐ No ☐ Unsure / maybe

Q 3.	1	2	3

Q 4. Would you use a computer program that calculated the costs to grazing operations of particular weed species, if all you had to do was enter the density of each weed into the program?

☐ Yes ☐ No ☐ Unsure / maybe

Q 4.	1	2	3

Q 5. If a new weed management tool was developed, providing impact data of weed invasions at a farm or paddock level, what features would you like it to have?

The following questions require a response on a scale of 1 to 5, where 1=strongly disagree, 2=disagree, 3=neutral, 4=agree and 5=strongly agree.

	1 strongly disagree	2 disagree	3 neutral	4 agree	5 strongly agree	
Able to quantify the impact of a weed species on pasture production						A
Able to quantify the impact of a weed species on stocking rates						B
Able to quantify the impact of a weed species on feed availability						C
Able to quantify the impact of a weed species on the environment						D
Able to quantify the impact of a weed species on livestock health						E
Able to quantify my loss in income						F
Able to provide a benefit:cost analysis of weed control						G
Able to explain how the weed spreads						H
It must be relevant to my area or region						I
It includes weed identification tips						J
It explains how to best control the weed						K
It is free to use						L
It is available on the internet						M
It is available as an application you can download onto your computer						N
It is available as a paper based version						O

Q 6. Are there any other features that you consider should be included in such a tool?

Details: _____

Q 7. If a decision support tool was developed to help farmers calculate the economic impact of weeds on their farm, which three weeds would you most like to see included in the tool?

1. _____

2. _____

3. _____

Q 8. Are there any other benefits you believe a pasture weed impact calculator could bring to graziers?

_____

_____

Q 9. What percentage of graziers in your area do you think might use such a tool?

_____%

Q 10. Do you currently use any of the following to help you manage grazing operations?

(a) Computer programs	**Y / N**	
(b) The internet	**Y / N**	

Q 11. In which age group do you fall?

<30 30-40 40-50 50-60 >60

Q 11.	**1**	**2**	**3**	**4**	**5**

Q 12. Do you have any questions or further comments about this concept of a pasture weed impact calculator?

_____

That completes the survey. Thank you for taking part.