

# ***Productive and Sustainable Salt-tolerant Pastures for South Australia and Victoria***

**FINAL REPORT - Victorian component**

Land & Water Australia Project:  
**UWA30**

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Project objective:

To significantly enhance the productivity and sustainability of salt tolerant, perennial grass-based pasture systems through the development of improved grazing management, nutrient strategies and pasture species options. This will provide options for livestock production from saline land that are profitable and reduce the environmental and social impacts of saline land.

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## MILESTONE 6 – FINAL REPORT

- 1 Key results and outcomes presented.
- 2 All data collated and added into national database.

### Achievement Criteria

Acceptance of report by Land and Water Australia

## Executive Summary

As part of the national Sustainable Grazing on Saline Lands project, an investigation was conducted into tall wheatgrass-based pastures as an option for saline land. The investigation covered pasture and animal productivity, biodiversity impacts, soil and water environment, and economic analysis.

Project activity was focussed on a grazing experiment located on a 20-hectare area of saline land near Dunkeld in western Victoria. Experimental treatments were (i) a volunteer control, (ii) commercially available cultivars (Dundas tall wheatgrass, Persian clover, Balansa clover and strawberry clover), and (iii) a pre-release line of *Melilotus albus*, with Dundas tall wheatgrass. The site was graded to form gentle mounds to improve drainage, followed by sowing in April 2003. It was grazed by maiden Merino ewes between late spring and early autumn, followed by wethers to control excess growth in autumn and for brief periods during winter and early spring.

Pasture growth during the first year was strongly negatively correlated to salinity in the topsoil. Growth of the sown pasture was nearly double that of the volunteer pasture at the same level of salinity. There were no significant differences in total pasture growth between the commercial sowing mix and the *Melilotus* treatment. However, *Melilotus* itself grew poorly and little remained after the first 8 months. Suckling clover (*Trifolium dubium*), a volunteer annual, then became the main legume on this treatment.

Sheep live weights increased slowly during summer on both the volunteer and sown pastures. Only slow gains were achieved on the sown pasture (6-25 g/head/day), and gains were marginally higher on the volunteer pasture (15-55 g/head/day). Summer is normally a time when sheep lose weight or require supplements when fed dry pastures on non-saline land. The sown pasture was able to carry nearly twice as many sheep per hectare during summer as the volunteer pasture.

Biodiversity measurements included counts of above-ground invertebrates, soil microbial biomass, microbial respiration, vegetation cover by species in spring, and Landscape Function Analysis (LFA). LFA is a method of assessing the health of the soil surface. It quantifies the proportion of bare ground, and provides indices of infiltration, stability and nutrient

cycling for the bare and vegetated areas. Most of these measurements were conducted on volunteer and sown treatments, and a nearby area of remnant vegetation on non-saline land.

Vegetative cover in spring on the sown and volunteer pastures had an average of 15% native species, with no significant differences between these treatments. There was therefore no case to retain the volunteer pasture purely for vegetation conservation purposes. There were, however, useful salt-tolerant native species within the volunteer pasture that would be worthwhile encouraging through grazing management. These species include salt couch (*Sporobolus virginicus*), which survives on highly saline land, and is able to spread into scalded areas. There is a case to retain old tree stumps for fauna conservation, because several nesting birds were found in them, along with an uncommon marsupial, the Fat-Tailed Dunnart. These species may prefer the volunteer pasture to the sown, but the study was unable to determine this. Also not studied was whether the flight-mobile insects (which were not caught in pitfall traps) preferred the volunteer pasture to the sown.

Soil and water measurements showed that on about half the site, salts were concentrated at the soil surface. This area had extremely high water tables, and it was difficult to establish pastures. On the other half of the site, salts were concentrated at a depth of 0.5 to 1.0 m. Water tables were lower, and pasture establishment was more reliable.

Soil testing of the topsoil showed that salinity levels varied about 3-fold during the year, with the lowest levels in late winter and the highest during summer. Values tended to be more stable during summer. Comparison with the Victorian vegetation-based salinity classification system for the plots these samples were collected from showed that the best fit range of salinity for Class 1 was 2-10 dS/m ECe, Class 2 10-29 dS/m, and Class 3 29-65 dS/m. At these boundary conditions, 13% of field readings were allocated to a class that was too low for their vegetation, and 12 % to a class that was too high.

The project showed that soil testing faces challenges of high spatial and temporal variation. Even where these challenges are overcome through a consistent sampling program, it does not provide a precise relationship with vegetation classes, because some soil test values close to boundaries overlap salinity classes. Soil testing does, however, provide continuous values rather than discrete classes. It is also strongly related to plant growth, and if undertaken at various times of the year, provides an explanation of the salinity stress faced by plants during a season.

Vegetation assessment is nearly instantaneous, is easily mapped by on-ground observation or hyper spectral imagery, and includes a "memory effect" of the highest levels of salinity encountered during the recent past. It is, however, unsuited to disturbed areas, and requires training.

Project recommendations are that vegetation assessment be used to determine management options for saline land. Class 1 land can be developed reliably with tall wheatgrass and annual legumes. Class 2 can also be sown, but there are not yet commercially-available legumes that can persist at these levels of salinity. Class 3 should only be sown if suitable volunteer

species are absent. It is better to encourage these species through separate fencing, because cultivation risks exposing bare ground for long periods while a pasture develops. Prior to the project, recommendations were to sow tall wheatgrass-based pastures on all classes of salinity.

Salt export in surface water averaged 3 tonnes/ha.year. This compares with salt stores of 250 to 900 tonnes/ha in the top 3 m. Assuming a linear rate of salt wash-off, it would take up to 300 years to clear these salt stores. Provided the salts can be safely stored within the discharge area, it is preferable to retain them than risk damaging streams by encouraging salt wash-off.

Economic analysis was undertaken for three farmer case studies using a discounted cash flow analysis. The case studies included tall wheatgrass at Hamilton and Seymour, and saltbush near Bairnsdale. These showed an internal rate of return over 20 years of between 20 and 32%. In each case, the unimproved carrying capacity was much lower than that achieved in the grazing experiment. This indicates that an alternative pathway to improving saline land could be to encourage salt-tolerant volunteer species (where suitable species are already present) by separate fencing.

The project made significant advances in identifying best practices for establishing and managing tall wheatgrass-based pastures. These practices form a chapter in a recently-released farmer-oriented book. The majority of salinity extension staff in Victoria have visited the research site, use findings in their own face-to-face advice, and welcome further contact with project staff.

The project has received excellent media coverage, with 41 articles appearing in print and electronic media.

## **TECHNICAL ASSESSMENT**

### **Project highlights**

- The Victorian component of SGSLS made significant progress in developing best practices for establishing and maintaining tall wheatgrass-based pastures for saline land.
- The benefits of these refined practices are evident in the high level of success achieved by a neighbour who owns land adjacent to the research site, and sowed a tall wheatgrass-based pasture in spring 2006.
- These best practices were published in a farmer-oriented book, which is used as supporting material in grazing industry training courses.
- This project, along with CMA incentive projects, has stimulated demand for tall wheatgrass seed well beyond the current capacity of the seed industry
- There has been good media interest in the project, with 41 articles published from the Victorian component alone
- A workshop with salinity extension staff attracted two thirds of the staff in Victoria that provide advice on saline land management, and the staff would welcome further such events

## Extent to which project objectives were met

Objectives at the start of the project are listed below, with comments on the success in achieving them.

### 1. To significantly enhance the productivity and sustainability of salt tolerant perennial grass-based pasture systems

This was achieved. During the course of the project many changes were made to best practice recommendations, including definition of where not to sow tall wheatgrass-based pastures. The productivity of the pastures were also benchmarked. The revised recommendations are now used in face-to-face advice in Victoria.

### 2. To determine the financial return from the systems under investigation

This was partially achieved. The returns from some producer sites were analysed using a discounted cash flow model, and showed internal rates of return of 20-32% (see the Economics section later in the document). A MIDAS analysis is still underway. This analysis was parameterised from the research site, and will be reported in the Economic Theme report.

### 3. Improve visual amenity and producer pride

This was achieved. The cooperating landholder was happy to be photographed with a green tall wheatgrass-based pasture, when the adjacent volunteer pasture looked poor. However, there are highly saline situations where planting to tall wheatgrass increased the proportion of bare ground. Under these situations, project recommendations are that the existing volunteer pasture be retained and encouraged through separate fencing.

### 4. Develop management strategies for tall wheatgrass-based pastures

This was achieved. There were insufficient experimental plots to investigate management strategies for tall wheatgrass-based pastures as a designed experiment. Instead, best management strategies were adapted from other similar species and applied to the experimental plots.

**Grazing management:** The pasture was not grazed between flowering and seedset of the annual legumes in the first year, to establish a good seedbank of annual legumes. A 4-paddock rotational grazing system was adopted for the sown pastures, based on studies of persistence in phalaris. This consisted of 1 week of grazing, followed by a 3-week spell. Rotational grazing provided good control of tall wheatgrass growth when it became reproductive.

**Fertiliser management:** An Olsen P level of 12-15 mg/kg was considered optimal based on perennial ryegrass on the Long-term Phosphate Experiment, and sufficient P was applied to ensure these levels. Potassium levels needs to be tested regularly, because K is rapidly leached out in wet years.

**Surface drainage:** A grader was used to improve surface drainage of the experimental site prior to sowing. After this level of ground disturbance, it was difficult to re-establish vegetation on the areas from which topsoil was removed from some areas. Following this experience, our recommendations are not to establish drains, and for minimal soil disturbance during pasture sowing.

## **5. Assess the weed potential of introductions, including tall wheatgrass, puccinellia and *Melilotus albus***

This objective was only partially fulfilled, because it relied on attracting a postgraduate (funded jointly with the Weeds CRC) to study the weediness of these species, and despite considerable advertising no-one was attracted to the role. Funds allocated to the half scholarship were redirected to provide more economic time, and pasture growth and surface water measurement. The intent of this objective was fulfilled in ways not foreseen at the start of the project. Firstly, Glenelg Hopkins CMA funded a study on the spread of tall wheatgrass, which found that there was little spread except by water, and that what spread occurred was believed to have been immediately after sowing. This study has been publicised through the SGSL project. Secondly, *Melilotus albus* failed to establish at the main research site, and did not persist at most other sites where it was sown in earlier trials. If it fails to persist its weed rating would be low. Thirdly, *Puccinellia ciliata* has already become endemic in salt-affected areas of the Upper South-East of South Australia through widespread sowing. Since it has already spread into these salt-affected areas, a weediness study by SGSL would be too late to limit its spread within this region. Furthermore, seed is no longer commercially available, which limits its spread to other regions.

## **6. Demonstrate to producers alternative commercial pasture options suitable for saline land**

This was achieved. The demonstration area was a focal point of interest for visitors. It showed that apart from tall wheatgrass and puccinellia (which were in the main grazing experiment), little else could tolerate the saline waterlogged conditions. Creeping saltbush grew well during summer, but suffered under the wet cold conditions of winter.

## **Conclusions and implications**

The Victorian component of this project has made excellent progress in developing establishment and management guidelines for tall wheatgrass-based pastures, measuring their productivity and assessing the financial benefits of sowing pastures on saline land. It has also promoted its findings through the media, to farmers and to salinity extension staff.

Saline land remains a difficult and unforgiving environment to establish pastures. It is highly variable spatially, and best management practices developed in one part of Victoria need to be modified to other situations. A follow-up phase will enable the scientific expertise built up during this project to be utilised in developing these solutions to other parts of Victoria, with the involvement of landholders and salinity extension staff so there is mutual learning.

# Project Assessment

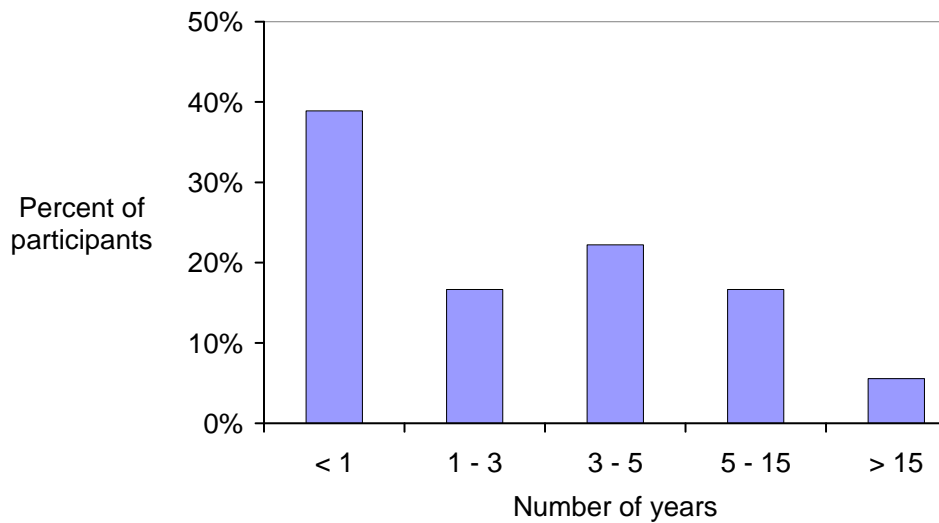
## Project outputs

### Communication activities

Details of external communication activities such as field days and farmer visits to the research site are listed below. There were 174 visitors in 11 groups. There was additional internal communication (within the SGSL group) that was not recorded, and included visits from the Victorian Regional Producer Network committee and SGSL theme leaders.

No.	Date	Group	No of visitors
1	4 Feb 04	Farmer field day	20
2	11 Feb 04	CRC Vic node visit	30
3	9 Sep 04	Tasmanian SGSL participants visited the SGSL site, including Dion Borg	5
4	15 Sep 04	SA SGSL research staff visited the SGSL site	5
5	13 Dec 04	CRC group with Austin Brown	20
6	16 Dec 04	Livestock Systems group, Hamilton, visited site	15
7	17 Feb 05	Site visit with Mike Wagg	1
8	18 Mar 05	Site walk with extension staff Dion Borg and Celia Affleck, including the project team	2
9	13 Sep 05	Rob Clark, DPI salinity vegetation mapping specialist	1
10	19 Sep 05	Saline Land Extension Workshop	30
10	6 Dec 2005	Farmer field Day	30
11	7 Dec 2005	Media tour arranged by Currie Communications	15

The Saline Land Extension Workshop was particularly significant as a way of communicating with next users. Many of these staff manage incentive payment schemes on behalf of CMA's, and are responsible for providing on-ground advice and setting conditions on the incentive payments. There are about 30 such staff throughout Victoria. At the time of the workshop, more than half the staff had less than 3 years of experience in providing advice on saline land management (Figure 1). This highlights a training need that SGSL could contribute to through its research results, products and experienced personnel.



**Figure 1. Number of years that salinity extension staff at the September 2005 workshop had been providing advice on saline land management.**

### Publications and products

The following publications were prepared during the project. Publication no. 9 is particularly significant, because it describes the best management practices based on the project's results, for a farmer audience. The first edition of the publication was produced 10 years ago and 3000 copies were sold, mainly to RIST who used it in delivering courses to farmers. Publications currently in preparation are described later in the report.

1. McCaskill MR, Bennetts D (2004) First-year production of salt-tolerant pasture in response to salinity and wetness. In. "Salinity Solutions". Proceedings of the Salinity Solutions Conference " Working with Science and Society" 2 - 5 August 2004, Bendigo, Victoria, Eds: Ridley A, Feikema P, Bennet S, Rogers MJ, Wilkinson R and Hirth J, (CRC for Plant-Based Management of Dryland Salinity: Perth) CD ROM
2. Marcar N, Mason W, Barrett-Lennard E, Masters D, Edwards N, McCaskill M, King W (2004) Profitable and sustainable grazing systems for livestock producers with saline land in southern Australia. In. "Salinity Solutions". Proceedings of the Salinity Solutions Conference " Working with Science and Society" 2 - 5 August 2004, Bendigo, Victoria, Eds: Ridley A, Feikema P, Bennet S, Rogers MJ, Wilkinson R and Hirth J, (CRC for Plant-Based Management of Dryland Salinity: Perth) CD ROM
3. Edwards NJ, Norman HC, Barrett-Lennard EG, Hebart ML, McCaskill MR, King WM, Mason W (2005) Australia's Sustainable Grazing on Saline Lands Initiative: a national research program. In "International Salinity Forum - Managing Saline Soils and Water: Science, Technology and Social Issues" Oral Presentation Abstracts. April 25-27 Riverside California. Ed. D. L. Suarez (University of California, Riverside, USA) pp 159-162.

4. McCaskill MR, Pollard T, Evans PM, Mavromihalis J, and Zollinger R (2005) Development of saline land technologies for temperate southern Australia. In “International Salinity Forum - Managing Saline Soils and Water: Science, Technology and Social Issues” Oral Presentation Abstracts. April 25-27 Riverside California. Ed. D. L. Suarez (University of California, Riverside, USA) pp 315-318.
5. Fitzpatrick L, McCaskill M, Hebart M (2005) Viable pastures for saline land: puccinellia and tall wheatgrass. Proceedings of the 46<sup>th</sup> Annual Conference of the Grassland Society of Southern Australia. Grassland Society of Southern Australia, Warragul (Ed J. Court) p 119
6. McCaskill MR, and Pollard T (2005) Summer weight gains from tall wheatgrass and volunteer pastures on saline land. Proceedings of the 46<sup>th</sup> Annual Conference of the Grassland Society of Southern Australia. Grassland Society of Southern Australia, Warragul (Ed J. Court) p 124
7. Edwards NJ, Masters DG, Barrett-Lennard E, Hebart ML, McCaskill M, King WM, Mason W (2005) Profitable and sustainable grazing systems for livestock producers with saline land in southern Australia. Proceedings of the XXth International Grassland Congress (“Grassland: a Global Resource”), Dublin, Ireland. Pp. 694
8. Edwards NJ, Norman HC, Barrett-Lennard EG, Hebart ML, McCaskill MR, King WM, Mason W (2005) Sustainable Grazing on Saline Lands: Profitable and sustainable grazing systems for livestock producers with saline land in southern Australia. Horizons in Livestock Sciences 2005 Conference, Gold Coast October 2005, Australia
9. McCaskill M, Borg D (2006) Pastures for saline areas. In “Greener Pastures for south-west Victoria” Second Edition (Ed Z Nie and G Saul) (Victorian Department of Primary Industries, Hamilton, Victoria) pp 90-98
10. McCaskill MR, Mavromihalis J, Zollinger R, Kearney G (2006) Soil analysis and vegetation as indicators of salinity. *ASSSI and ASPAC National Soils Conference - Soil Science Solving Problems. Adelaide 3-7th December 2006* p 13
11. McCaskill MR, Rogers MJ (2007) NyPa Forage<sup>TM</sup> – a new grass for highly saline areas. Agriculture Note AG1290, Department of Primary Industries, Victoria, Australia.
12. McCaskill MR, Borg D (2007) Legumes for saline areas. Agriculture Note AG1295, Department of Primary Industries, Victoria, Australia.
13. Antonoff G, McCaskill MR (2007) Saltbush for saline land. Agriculture Note AG1294, Department of Primary Industries, Victoria, Australia.
14. Bennetts DA, Webb JA, McCaskill M, Zollinger R (2007) Dryland salinity processes within the discharge zone of a local groundwater system, southeastern Australia. *Hydrogeology Journal* **15**, 1197-1210
15. McCaskill M, Zollinger R, Bennetts D, Kearney G (2008) Salt storage and wash-off from saline land in a winter rainfall environment. 2<sup>nd</sup> International Salinity Forum: Salinity, water and society: global issues, local action. 31 March-3 April, Adelaide (Richard Price, Convener) CD ROM

## Press articles

Over the life of the project, a total of 41 articles were published in various forms of news media. Many of the articles arose from the Stockowners column produced by DPI Hamilton for the Hamilton Spectator, but also sent to other regional newspapers that also print the article if it is interesting and relevant to their readers. The other significant route of articles was from a Ministerial press release, which was reported in many newspapers including a Melbourne metropolitan daily, the Herald Sun. Positive publicity within DPI (such as DPI News) should not be undervalued, because of its role in formulating policy such as heading off weed declarations for tall wheatgrass.

<b>No.</b>	<b>Date</b>	<b>Article</b>	<b>Comments</b>
1	July 03	Hamilton Spectator Stockowners	Submitted
2	August 03	Stockowners article reprinted in newsletter of North Central CMA	By request
3	26 Jan 04	Interview with 3HA re paddock walk 4 Feb 04	By request
4	14 Feb 04	Hamilton Spectator article	By request, following Paddock Walk
5	1 Mar 04	Across The Board (DPI Wool Program internal newsletter)	Submitted
6	19 Apr 04	3WM interview with David Berry, aired on ABC Country Hour (Vic) 20 April	By invitation, through Currie Communications
7	29 April 04	Stock and Land full-page article	By invitation, through Currie Communications
8	May 04	Article in Western District Farmer "Salt-affected land can be profitable" by Brian O'Brien	
9	29 May 04	Hamilton Spectator "Saline Flats: a liability or an asset?" (page 20)	Stockowners column
10	2 June 04	West Wimmera Advocate	Stockowners column reprinted
11	5 June 04	Western Districts Farmer "Saline Flats: a liability or an asset?" (page 4)	Stockowners column reprinted
12	17 June 04	Warrnambool Standard	Stockowners column reprinted
13	22 Aug 04	Ministerial Press Release	By invitation
14	28 Aug 04	Article in Hamilton Spectator "Dundas wheatgrass can double yields in saline soils"	From press release
15	2 Sep 04	Article in Mallee Ag News "Scientists Double Wheat Grass Production in Saline Soil"	From press release
16	1 Sep 04	Article in Casterton News "Scientists Double Grass Production"	From press release
17	25 Aug 04	Article in West Wimmera Advocate "Wheat Grass production in Saline soil doubled"	From press release

<b>No.</b>	<b>Date</b>	<b>Article</b>	<b>Comments</b>
19	23 Aug 04	91.19 STAR FM BENDIGO Radio News – “A new way of making sure saline paddocks are useful”	From press release
20	23 Aug 04	BENDIGO 3B0 Radio News - “A new way of making sure saline paddocks are useful”	From press release
21	25 Aug 04	Article in Herald Sun “Better Pastures”	From press release
22	24 Aug 04	Article in Sunraysia Daily “Wheat grass shows pasture promise”	From press release
23	27 Aug 04	Article in Bendigo Advertiser “Salinity research shows benefits”	From press release
24	26 Aug 04	Article in Warrnambool Standard “Fodder doubled on saline land – Grazing research results look encouraging”	From press release
25	25 Aug 04	Article in Alexandra Eildon Marysville Standard “Grass production doubled in saline soil areas”	From press release
26	Sep 04	Article in North East Farmer “Scientists double wheat grass production in saline soil”	From press release
27	Oct 04	Article in Western District Farmer “Scientists double wheat grass production in saline soil” (page 17)	From press release
28	1 Jan 05	The year that was in farming – Hamilton Spectator	Written by journalist, developed from earlier press release
29	4 Jul 05	DPI News – “PIRVic Hamilton Cleans Up Poster Competition at Grassland Conference”	Submitted by Kim Bege of DPI media unit
30	July 2005	DPI Hamilton Centre Newsletter– “PIRVic Hamilton Cleans Up Poster Competition at Grassland Conference”	Submitted by Kim Bege of DPI media unit
31	25 Aug 2005	“From Saltland to Profitable Pasture”, Stock and Land	Paid space in CRC insert
32	28 Aug 2005	Saline Land Practice Change workshop – DPI News	Submitted
33	10 Oct 2005	Photo of Hamilton Project Site Wins \$1000 Award – DPI News	Submitted by Kim Bege
34	3 Dec 2005	Saline land findings to be showcased at field day – Western Districts Farmer	Submitted by Malcolm McCaskill
35	17 Dec 2005	Battle continues – controlling salinity remains a contest. Hamilton Spectator	Written by Spec journalist following media tour
36	29 Dec 05	Keeping salt at bay. Stock and Land	From LWW Media tour

No.	Date	Article	Comments
38	11 Jan 06	Natives for saline land ? Loddon Times	Submitted as Stockowners column for Hamilton Spectator
39	14 Jan 06	Native pastures for saline land ? Hamilton Spectator	Submitted as Stockowners column
40	Feb 06	Native pastures for saline land ? Western Districts Farmer	Submitted as Stockowners column
41	Autumn 2006	Native pastures for Saline land ? DPI News and Views, North Central Victoria's Farming Newsletter	Reprinted from Stockowners column

## Project impacts

### Evidence that results are useful

Project findings are being applied successfully on saline land in the Glenelg-Hopkins area. According to Dion Borg, a local salinity extension officer, recommendations prior to the project were to plant tall wheatgrass on all classes of salinity. The SGSLS findings have changed these recommendations to allow for salinity class. On Class 1 and 2, tall wheatgrass is still recommended, but Class 3 should be fenced off separately sowing should only be contemplated if existing plants provide insufficient ground cover. The project has also shown that ground disturbance should be minimised.

Dion Borg also said that SGSLS findings are much easier to pass onto new salinity extension staff than the accumulated anecdotal information that existed previously. The findings are rigorous and available in information products, which makes training of new staff much easier and more effective.

An evaluation sheet at the final field day (6 December 2005) asked participants to score responses to questions between 1 (a little) and 5 (a lot). Questions were

1. To what extent has the field day increased your confidence in managing saline land? (median score 3)
2. How relevant to you are tall wheatgrass based pastures? (median score 4)
3. How relevant to your are native pastures on saline land? (median score 4)
4. Do you expect to use the handout material? (median score 4)

### Evidence that activities have been valued

The Saline Land Extension Workshop, held in September 2005, attracted 19 salinity extension staff, or about two thirds of such staff in Victoria. Some were unable to come because of holidays, or providing advice on saline land was only a minor part of their role. All extension staff had positive comments on the workshop, and would like similar meetings to be held more regularly. Comments from after the event were "It was valuable for staff to come", and "Previously we couldn't readily find the information we needed". "Participants look back on the event as something that impacted them". Some have continued to seek advice from Dion Borg (who spoke at the workshop on tall

wheatgrass management and is now one of the most experienced salinity officers in Victoria) about difficult issues in saline land management.

Responses were captured from extension staff at the workshop immediately after a visit to the research site. These included (i) a need to be careful with mounding, (ii) the benefits of using a mixture of species to accommodate the range of salinity encountered at a site, and (iii) the benefits of including puccinellia in a sowing mix.

Field days for farmers attracted 50 participants, most of whom were from the local area. This is probably because salinity is a problem on a small portion of properties in Victoria, and landholders do not see it worthwhile to travel a long distance to see a trial site. After the experimental phase finished, local salinity extension staff have taken 2 Landcare groups to the site, each with 5-10 people. Such visits are likely to continue long after the research project itself has finished.

### Evidence that publications and products are in demand

Several salinity extension staff who began working in saline land management after the Saline Land Extension Workshop asked for a CD of the presentations and other information.

The book “Greener pastures for south-west Victoria” has drawn the following comments

“It’s the best-written book we’ve ever seen” – Bruce Donaldson, farmer, Mortlake

“I’ve thrown all the other books in the bin and just use this one” – Matt Kennedy, salinity extension officer, Creswick

“ It has the best information I’ve seen on pastures” – Lindsay Hyde, team leader of DPI Sustainable Landscapes, southern section, Frankston

While these comments are made for the whole book, the greatest interest of the 3 people quoted was the chapter “Managing Plants in Saline Areas”

Local salinity extension staff send out A4 copies of conference posters prepared by the research project in response to queries, particularly on weight gains from saline land, and the economics of improving saline land.

### Evidence of impact on target audiences

At the start of SGS in 2002, the company with the rights for producing Dundas tall wheatgrass seed (Wrightsons) had large stocks, and were fearful the plant would be declared a weed. By 2006, demand for tall wheatgrass seed was outstripping supply by a factor of 4 to 1, and there is a waiting list for 15 tonnes of seed. While SGS cannot claim full responsibility, the positive publicity from the project (41 articles from the Victorian site alone), along a study on the spread of tall wheatgrass funded by Glenelg-Hopkins Catchment Management Authority, incentive programs for planting saline land under the National Action Plan for Salinity and Water Quality, and planning processes within CMA’s have helped bring about this dramatic change.

Seed production manager for Wrightsons, Bruce Guy, believes the annual market is about 40 tonnes/year. Contracted seed production under irrigation in South Australia are likely to produce 5-10 tonnes in 2007, and Wrightsons are aiming to produce as much as they can in 2008. Gearing up production is slow, because there is normally a 2-year period between sowing and the first seed crop.

A farmer whose land adjoins the SGSL research site recently put the findings into practice by sowing a tall wheatgrass-based pasture in spring 2006. The pasture is nearly weed-free and is developing well. He has also sown a much larger area under a grant incentive scheme. The pastures are currently looking much better than on the research site, because the agronomic advice is built on accumulated knowledge from SGSL made available through local salinity extension staff.

A new salinity extension officer at Wagga Wagga, Paula Charnock, asked Dr McCaskill how to measure treatment impacts on saline land, and requested a copy of the CD compiled from project publications and presentations at the Saline Land Extension Workshop. When asked for feedback, she said that the CD was useful, but not as useful as being able to talk to Dr McCaskill. She said that it was useful for extension staff to have the information on the CD, but that Powerpoint slides alone didn't communicate as well as being at the workshop.

## Project Results

This section is based on abstracts of some published papers and unpublished early drafts of journal papers, listed below:

No.	Title/topic	Authors	Journal
1	Dryland salinity processes within the discharge zone of a local groundwater system, southeastern Australia.	Bennetts, Webb McCaskill Zollinger	Journal of Hydrology (published)
2	Soil analysis and vegetation as indicators of salinity	McCaskill Mavromihalis Zollinger Kearney	Australian and New Zealand Soil Science Society Proceedings, Dec 2006 (published)
3	Salt-tolerant pastures for temperate southern Australia. Pasture growth and persistence	McCaskill Zollinger Kearney Mavromihalis	Australian Journal of Experimental Agriculture (in preparation)
4	Salt-tolerant pastures for temperate southern Australia. Animal production	Pollard McCaskill Kearney Zollinger Tocker Fitzpatrick	Australian Journal of Experimental Agriculture (in preparation)
5	Soil analysis and vegetation as indicators of salinity	McCaskill Mavromihalis Zollinger Kearney	Australian Journal of Soil Research (in preparation)

## Paper 1. Dryland salinity processes within a discharge zone of a local groundwater system, southeastern Australia

### Abstract

Examination of the geology, hydrogeology and hydrochemistry of a groundwater discharge zone affected by dryland salinity in southeastern Australia has allowed the relative importance of the factors identified as leading to the development of dryland salinisation to be discerned. The most important requirement for the development of salinisation is a shallow watertable (1-2 m from the surface). Direct evaporation at the watertable, particularly in summer, concentrates salts contained within the groundwater, leading to extremely high soil-water salinities at the surface, even if the underlying groundwater is moderately fresh. Sediment permeability also plays a major role in acquiring and retaining salt in the groundwater discharge zone. The highest salt concentrations are in the lowest permeability clay-rich sediments. The low hydraulic conductivity of these sediments increases the time water moving through them is exposed to evapotranspiration, and reduces the potential for salts to be flushed from the sediments. The groundwater discharge zone at the study site occurs at a break in slope, partly because this is where the sloping watertable intersects the surface. In addition, this is where finer, more clay-rich sediments with lower permeability inhibit lateral groundwater flow and force it upward to the surface. Salts accumulated at or near the surface in summer may be flushed from the more permeable sediments at the beginning of major runoff events, increasing the salinity of nearby waterways. Therefore any salinity risk assessment must take into account the proximity of the watertable to the surface, the dynamics of the seasonal watertable oscillation, the permeability of the underlying sediments, and the topography.

NB. The full paper has been published in *Hydrogeology Journal*, reference 14 above

## Paper 2. Soil analyses and vegetation as indicators of salinity

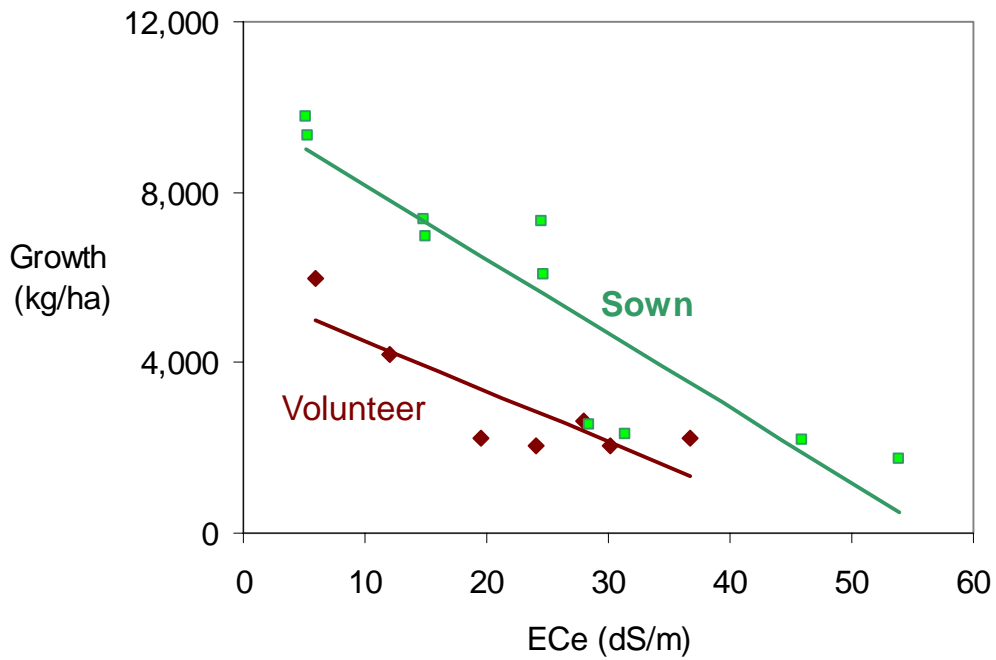
### **Abstract**

Successful establishment of pastures into saline land relies on sowing species that can tolerate the temporal and spatial variation in salinity at a paddock scale. Recommendations in Victoria are currently based on indicator species, supplemented with soil tests from the best and worst areas. However, indicator species are not a reliable indicator of salinity where there has been overgrazing or soil disturbance. To develop confidence in relationships between plant indicators and soil tests, soil samples were taken monthly over a 2-year period and analysed for the electrical conductivity of the saturation paste extract (EC<sub>e</sub>). Samples (0-10 cm) came from a grazing experiment near Dunkeld in southern Victoria, which included 7 transects on unsown areas, and 11 on sown areas. EC<sub>e</sub> was generally highest during summer (December to April), declined to 30% of summer values for brief periods during winter, and then rose again early in spring. Vegetation indicative of mild salinity generally occurred within a summer EC<sub>e</sub> range of 2-10 dS/m, that indicative of moderate salinity at 10-29 dS/m, and that indicative of severe salinity at 29 to 65 dS/m. These ranges are much higher than have been developed with the same indicator species in northern Victoria. Separate sampling of bare and vegetated areas on 3 occasions indicated that, depending on sampling time, the bare areas were 3 to 10 times as saline as adjacent vegetated areas. It is therefore important that the sampling strategy accounts for this spatial variation.

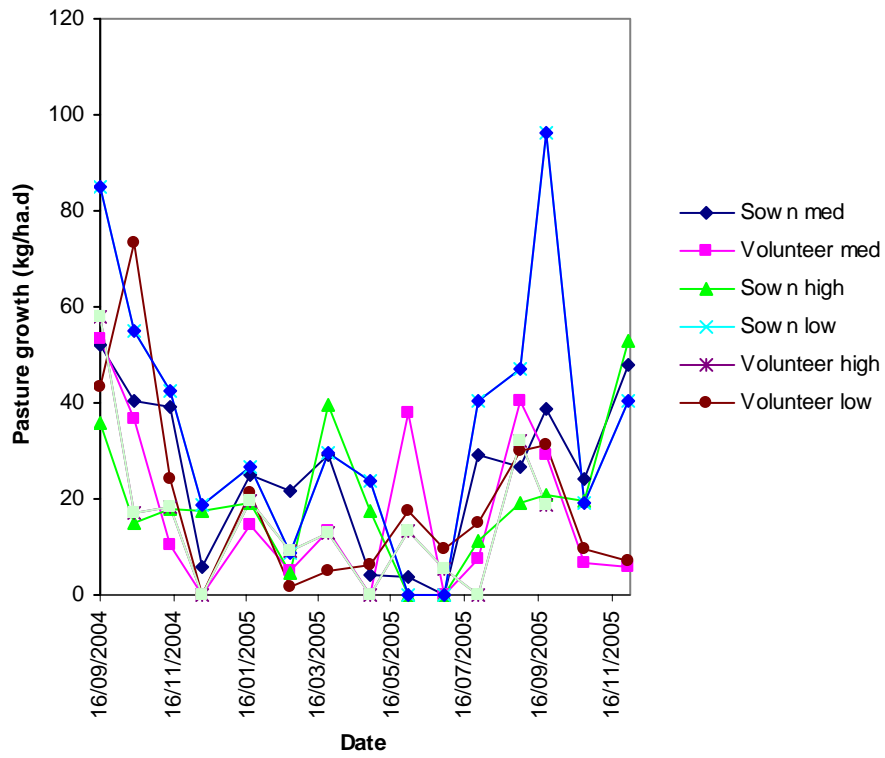
NB. The above abstract was published in the conference proceedings, reference 10 above

### Paper 3. Salt-tolerant pastures for temperate southern Australia. Pasture growth and persistence

This paper will report pasture growth in response to salinity, and botanical composition during the period of the experiment. Two key graphs are shown below.



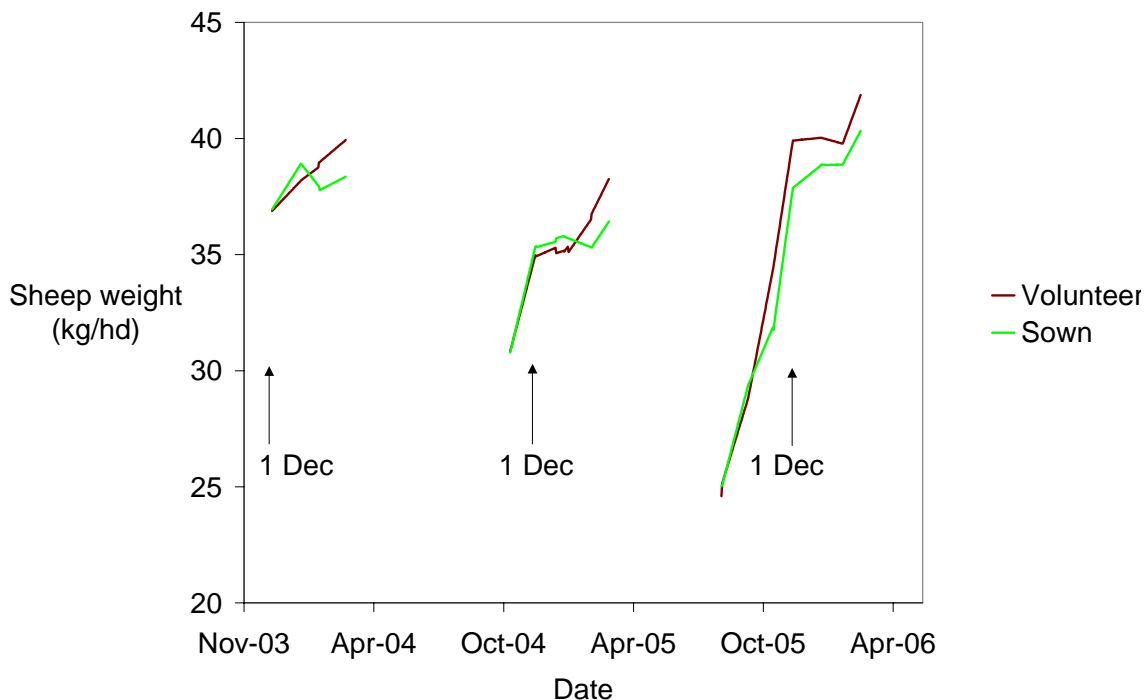
**Figure 1. Pasture growth between April and December 2003 and in relation to topsoil salinity measured in December 2003.**



**Figure 2. Pasture growth measured in exclusion cages for sown and volunteer pastures at low, medium and high salinity levels.**

## Paper 4. Salt-tolerant pastures for temperate southern Australia. Animal production and economic analysis

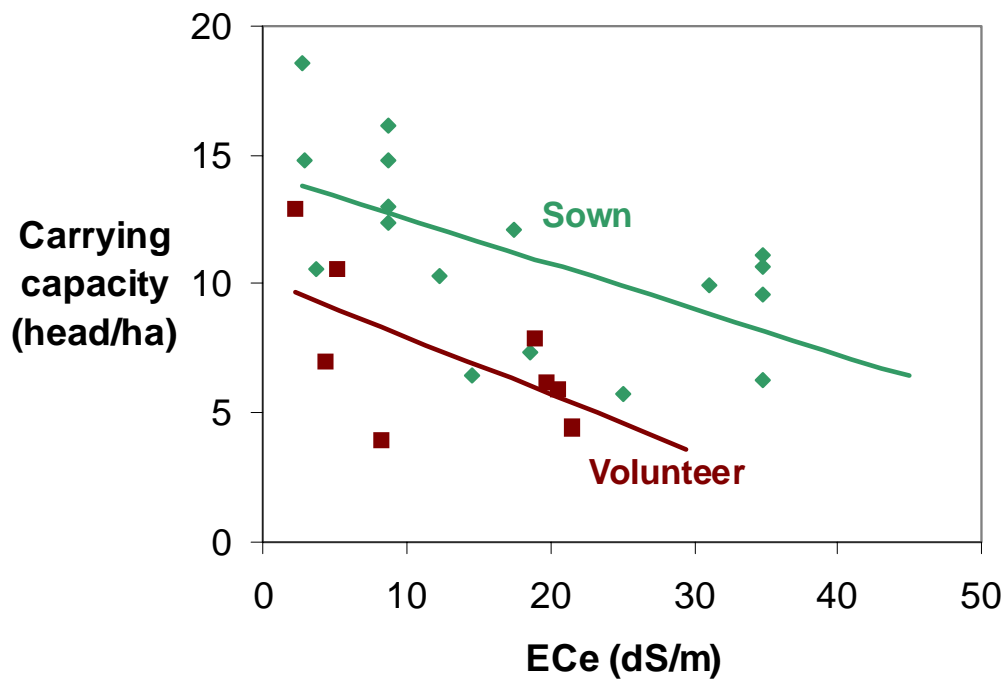
This paper will cover live weight gain and carrying capacity of the research site, and financial returns from the producer network sites. Key graphs of weight gain and carrying capacity are shown below. The economic analysis is summarised in the “Economics” section below.



**Figure 1. Mean weight of the maiden ewes on volunteer and sown pastures.**

Maiden ewes grazed the site over the spring-summer period, and gained weight rapidly during spring. However, as the pasture matured at the start of December, weight gain occurred only slowly (Fig. 1). Weight gains were slightly greater on the volunteer pasture than the sown. Rainfall in late summer of 2005 and 2006 caused more rapid weight gains toward the end of summer.

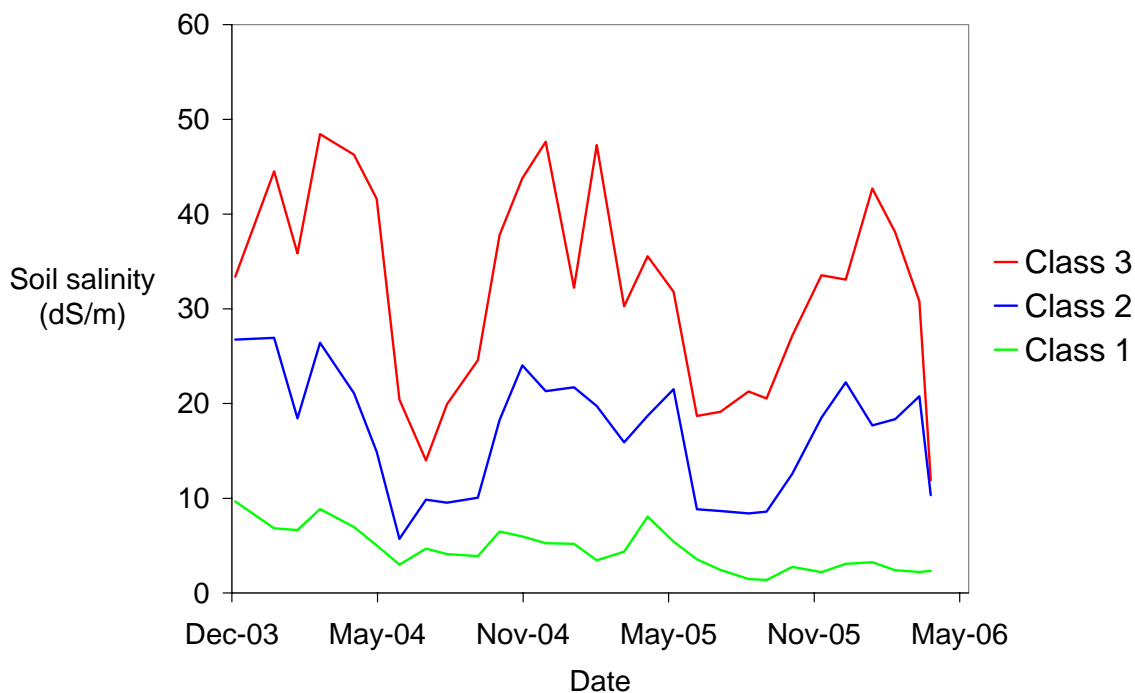
Carrying capacity was increased by 5 sheep/ha through pasture sowing (Fig 2).



**Figure 2. Mean stocking rate for the sown and volunteer pastures, compared with the median ECe for each plot.**

## Paper 5. Soil analysis and vegetation as indicators of salinity

This paper will be developed from a conference paper of the same title (Paper 2), and addresses a question raised by salinity extension staff about the correspondence between soil tests and the Victorian vegetation classes. It uses monthly soil 0-10 cm ECe data from pastures of various salinity vegetation classes on the research site over a 2.3 year period. The analysis was conducted separately for volunteer and sown pastures for Class 1 (mild), Class 2 (moderate) and Class 3 (severe) salinity. Within each class, values fluctuated about 3-fold between summer and winter (Fig 1).



**Figure 1. Soil salinity (ECe, 0-10 cm) for the various vegetation classes.**

Statistical analysis using smoothing splines to develop a confidence interval for the mean of each class and pasture type, showed that the 95% confidence intervals do not overlap (Fig 2). The interval for each class is higher in summer than winter. The approximate range of ECe (dS/m) for summer is

Class 1	2-10
Class 2	10-25
Class 3	25-65

These values will be refined when statistical analysis is completed.

## General discussion and conclusions

This section is based on results presented earlier in the report as draft or concept papers, as well as findings already published in conference papers.

### Salt and water movement

Of sites within the SGSL research network, the Victorian site had the freshest groundwater (2 dS/m), but in some parts of the site had the highest topsoil salinity levels (up to 88 dS/m ECe). This is because persistently high groundwater levels allowed salts to concentrate at the surface through soil evaporation. Establishment of tall wheatgrass-based pastures was difficult in such areas, but once established the plants grew well because they could access deeper fresh water.

Data on surface water and salt movement recorded in a flume draining about a third of the site showed that 3 tonnes/ha of salt would normally be washed off per year. This compares with salt stores of 100 to 550 tonnes/ha in the top 1 m of soil, or 250 to 900 tonnes/ha in the top 3 m. At a linear rate of wash-off, it would take up to 300 years to clear the salt store. Because of the damage this would cause to streams and water users, it is preferable to retain salt within the discharge area rather than damage streams and limit downstream use of the water.

The pattern of salt accumulation in the soil profile showed marked differences across the experimental site. In the northern part of the site, salt concentrations were highest at the surface, but low at depth. In the central and southern parts of the site, salt concentrations were highest at a depth of 0.5 to 1.0 m and only modest at the surface. The northern part of the site was closest to the sandy ridge that provided much of the recharge. Water tables were consistently high, facilitating upward movement of salt by capillary movement. Salts were then concentrated at the surface by soil evaporation. Germination and establishment of sown pastures was difficult in this part of the site. The central and southern parts of the site had lower water tables, and germination and establishment of sown pastures was more reliable.

A suggestion in Paper 1 (Dryland salinity processes within a discharge zone of a local groundwater system, southeastern Australia) is that engineering options could be suitable for areas such as the northern part of the research site, because the groundwater is relatively fresh. Subsurface drainage as practiced in irrigation areas would cause the net water and salt movement to change from upward to downward. Salts would no longer accumulate at the surface. The experience of local landholders is that the initial flows of a drain are saltier than streamwater, until the surface salt store is washed through, after which the drain flows are fresher than streamwater, and can be used for stock water or irrigation.

One approach to salinity management is to locate salt stores using remote sensing, and establish vegetation on these areas that minimise leakage to groundwater. This approach would not be suitable in this case, because the adjacent recharge areas have relatively fresh groundwater and thus little salt storage. The recharge area would not be shown as a significant salt store and thus not prioritised for treatment. Salinity in the discharge area is caused by a high water table, which allows the small amount of salt in the groundwater to be concentrated at the surface. Options for treatment of salinity in this case are

- reduce recharge on the sandy hill to the north of the site, through vegetation with a high water use such as trees, lucerne or kikuyu

- establish a vigorous salt-tolerant pasture on the discharge area, to reduce soil evaporation and enable salts to be retained deeper in the profile, with a maximum salt concentration between 0.5 and 1.0 m depth
- subsurface drainage of the worst-affected areas, to minimise salt accumulation at the surface.

## Siting, establishment and production of saltland pastures

Several important advances have been made in the agronomy of establishing tall wheatgrass-based pastures through this project. These are already being delivered in face-to-face advice in saline land management in south-west Victoria, and are available in a farmer-friendly form through the book chapter on Pastures for Saline Areas (publication 9 above). The advances are

1. The Victorian Salinity Class system should be used to determine agronomic options.
2. Class 1 (mild salinity) requires good weed control, but has the potential to grow a productive pasture with a high proportion of tall wheatgrass. Annual legumes should be sown the year after tall wheatgrass. (If sown with tall wheatgrass, the vigorous annual legumes shade out and eventually kill the tall wheatgrass seedlings).
3. Class 2 (moderate salinity) should be prepared with minimal cultivation to avoid salts rising to the surface. Tall wheatgrass will persist, but not the current commercially available legumes. Puccinellia is a useful addition to the seed mix, to increase the chance of success in difficult areas. Nitrogen application is necessary to maintain tall wheatgrass vigour, unless there are already adapted volunteer legumes.
4. Class 3 (severe salinity) should be fenced separately, and sowing should only be contemplated if the volunteer species are not providing good cover. The seed mix should contain both tall wheatgrass and puccinellia.
5. Spring sowing gives an even nearly weed-free pasture, but because wet conditions in saline areas restrict access to cultivation equipment, spring sowing is only possible in dry years.
6. Saline areas need regular soil testing for potassium, because this element can be leached out (upward) much more rapidly than on non-saline land.
7. A tall wheatgrass pasture should be fertilised for P to ensure the Olsen P is between 12 and 15 mg P/kg.
8. Tall wheatgrass should be rotationally grazed to maintain better control and reduce the risk of its tillers becoming reproductive.

With the benefit of these findings, new tall wheatgrass-based pastures are expected to be much more even, productive and persistent than those sown at the SGSL research site.

Creeping saltbush grew well during summer, but there was net loss of plant material in the cold waterlogged conditions of winter. There is little prospect of saltbushes being useful in this environment unless there is evidence that they are tolerant of wet cold conditions.

The volunteer control on the research site had a much higher carrying capacity than pre-treatment values from the regional producer network (see Table 1, next section). The long history of salinity had presumably selected species that tolerant of salinity, waterlogging and grazing. The volunteer pasture on Class 2 salinity was based on buckshorn plantain (*Plantago coronopus*, an introduced species), salt couch (*Sporobolus virginicus*, a native species), and suckling clover (*Trifolium dubium*). Both buckshorn plantain and salt couch grew well during summer, and were high in digestibility. The SGSL research project has given a greater appreciation for volunteer species on

saline land. Where these species are present, separate fencing can encourage them. This should lead to productivity improvements without the costs of sowing. This option may be particularly attractive to landholders with only small areas of salt-affected land.

Suckling clover (*Trifolium dubium*) is a naturalised volunteer legume at the site that is tolerant of Class 2 salinity. Although its yields were low, it was persistent and also tolerated red-legged earth mite, and may be worthwhile propagating to other Class 2 areas. There are currently no commercially available legumes tolerant of Class 2 salinity. Another introduction tested in an adjacent plant selection trial, *Lotus tenuis*, was also persistent under Class 2 salinity, and it is hoped that this will be commercialised in the future.

## Performance and animal production

The sown pasture was able to carry 5 sheep/ha more than the volunteer at all levels of salinity. At high levels of salinity, this was through isolated tall wheatgrass plants surrounded by large areas of bare ground, whereas at the lower salinity levels there was an even pasture with little bare ground. While pasture sowing at high levels of salinity was able to increase carrying capacity, the tradeoff of increased bare ground would be unacceptable to most landholders.

The increased carrying capacity of sown pastures during summer came at another cost – lower per animal live weight gain. However, during summer to simply maintain weight is an advantage over dry pastures on non-saline land, where the stock either lose weight or a supplement is required to hold weight.

The study showed that at a low stocking rate of 5 sheep/ha, sheep growth rates of up to 55 g/d can be achieved on a good volunteer pasture on Class 2 land. On properties with large areas of saline land, this could be significant for maintaining the growth of certain classes of stock during summer.

Both volunteer and sown pastures responded to rain in late summer, as evidenced by weight gains at the end of summer in 2004 and 2005. Pastures responsive to summer rainfall and are also safe for stock are a valuable complement to perennial ryegrass-based pastures, which often cause ryegrass staggers if they respond to summer rain.

## Economics

Two forms of economic analysis were conducted in the Victorian research component of SGSL. Firstly, a discounted cash flow analysis was conducted on results from 3 Regional Producer sites. This included one near Hamilton, which had been planted Dundas tall wheatgrass several years before the research trial commenced. Secondly, MIDAS was used to examine the impact of saltland pastures on whole-farm profitability, particularly synergies with non-saline land. The MIDAS analyses will be reported in the Economic Theme report.

The 3 Regional Producer sites used in the discounted cash flow analysis were at Hamilton (40 hectares of tall wheatgrass), Bairnsdale (16 hectares of saltbush), and Seymour (8 hectares of tall wheatgrass). Results are summarised in Table 1.

**Table 1. Summary of Economic Case Studies**

Case Study	Treatment	Carrying Capacity Unimproved	Carrying Capacity Improved	Pasture Establishment Costs per ha	Fences & Water Establishment Costs per ha
<i>Hamilton</i>	Tall Wheat Grass	2.5 dse/ha	15.5 dse/ha	\$398	\$67
<i>Bairnsdale</i>	Saltbush	1.2 dse/ha	14.6 dse/ha	\$1,042	\$224
<i>Seymour</i>	Tall Wheat Grass	2.5 dse/ha	15.5 dse/ha	\$571	\$250

Case Study	Net Present Value 10Yrs	Net Present Value 20Yrs	Internal Rate of Return 10Yrs	Internal Rate of Return 20Yrs	Payback Period (Years)
<i>Hamilton</i>	\$13,718	\$32,440	19.0%	22.7%	4.6
<i>Bairnsdale</i>	\$6,255	\$16,076	15.7%	19.7%	5.2
<i>Seymour</i>	\$3,873	\$7,279	29.6%	31.8%	3.6

The main driver that influences whether it is economic to establish saline pastures in saline soils is the increase in stocking rate over an unimproved pasture. If the new saline pastures only sustain a low stocking rate then it is uneconomic to pursue establishing new species. The results show that average carrying capacity has increased from 2 dse/ha to 15 dse/ha, an average increase of 13 dse/ha.

Pasture establishment costs per hectare vary from \$398 for Hamilton, which had the larger block of 40 hectares, and \$1,042 for Bairnsdale, which had 6 hectares hand planted with seedlings. All case studies show strong internal rates of return, i.e. the average rate of return on the investment over time, and positive net present values. This is supported with payback periods ranging from 3.6 to 5.2 years. On average the investment of establishing new pastures will be paid back within 4.5 years.

A factor not yet considered in the economic analysis is the influence of the area of saline land that can be enclosed within a separate paddock. Since the median size of contiguous areas of saline land in Victoria is 13 hectares, there would be a large number of small paddocks that may not justify the costs of separate fencing, water points and sowing based on financial benefits to the landholder alone. Here there is a case for public investment by way of extension, fencing costs and pasture sowing, to protect stream flows from erosion and salinity.

## Biodiversity

The most significant finding in the biodiversity component of the project is that pasture sowing increased the proportion of bare ground, particularly at high levels of salinity. To avoid inadvertently increasing bare ground through pasture sowing, site classification using vegetation indicators is a first step to avoid attempting to sow tall wheatgrass on areas that are too saline for it to establish. Secondly, cultivation passes should be minimised to avoid salts rising to the surface when there is no plant cover.

The volunteer pastures did not have a significantly higher proportion of native species than the sown pasture. At this site, there is therefore not a case to preserve the volunteer pasture for conservation reasons. There are, however, useful native species in the volunteer pasture that are

worthwhile maintaining for production purposes. Most notable among these is salt couch, *Sporobolus virginicus*, which is tolerant of Class 2 and 3 salinity, and produces green feed of moderate digestibility during summer. Furthermore, salt couch is able to colonise saline scald areas through stolons.

The site had a long history of grazing, which would have favoured species that were tolerant of salinity, waterlogging and grazing. This may account for the low proportion of natives in the volunteer pasture. Each site would need to be assessed on its merits, as to whether there are sufficient native species to protect the site for conservation reasons.

Data from the invertebrate survey and microbial biomass did not indicate strong reasons to either develop or retain volunteer pasture on saline land. Any decision on pasture sowing would need to be made for other reasons such as landholder preferences or productive capacity.