The national newsletter of salinity R&D

focus ON SALT

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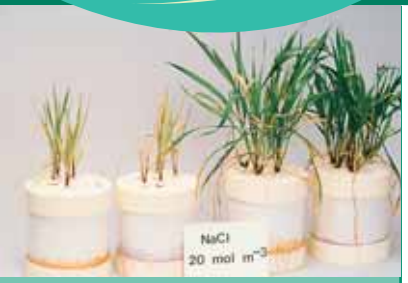

Waterlogging with salinity — bad mix for wheat (page 4)

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CRC FOR PLANT–BASED MANAGEMENT OF DRYLAND SALINITY

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Thumbs up for saltbush

Saltland pastures can be profitable and contribute to the environment, but getting the formula right is essential, according to new *Sustainable Grazing on Saline Lands (SGSL)* findings.

Photo: H Norman

Rotational grazing of saltbush

Research results from four years across four States were summarised at a national forum in Ballarat in September. Although drought had severely limited conclusions in several eastern State trials, results from Western Australia gave a resounding vote of confidence for saltbush.

CRC Salinity researcher Dr Hayley Norman (CSIRO Livestock Industries) provided results from four farm sites, which aimed to determine the feeding value of saltland pastures for meat and wool production, while assessing financial returns and other impacts.

While the locations and seasons varied, measurements showed that edible biomass or available feed was higher on saltbush plus sown understorey, or saltbush plus volunteer species, than on volunteer pasture (predominantly barley grass) except in the good 2005 season where results were very close for all three grazing systems.

Even better, the stock actually liked those salty leaves! However, sheep are unlikely to maintain condition on saltbush alone. Associated animal house studies reveal that sheep do not ingest more than 200 grams of salt each day or about 800 g of saltbush biomass. To maintain condition the animals need some supplements or good quality understorey species.

Researchers found that sheep chose to eat more saltbush in summer and autumn, when there is generally less other quality feed on offer, than in other seasons. However, in spring when ample alternative high quality feed was available, they still included about 10 per cent saltbush in their diets, increasing this to 50% in autumn when alternatives were thin on the ground and less digestible (see Figure 1 on page 2).

Over the four WA farm sites the numbers and density of saltbush varied considerably from around 330 shrubs per hectare at Tammin, to 900 at one Yealering property. Edible biomass growth from each shrub ranged from 0.5 to 1.4 kilograms per year, again emphasising the need for understorey or supplements.

As an autumn feed for maintaining dry sheep, saltbush does well in providing crude protein for stock compared with puccinellia and other salt-tolerant grasses, but lags in the energy stakes. This emphasises the importance of carefully targeting revegetation to get the best economic return and ensuring the understorey is right, a process greatly assisted by the water-use capacity of saltbush.

Dr Norman said MIDAS whole-farm modelling showed a break-even return on investment at a moderately saline site in Tammin, where $240/ha was the maximum establishment cost for the saltbush and pasture. However, at a less saline site in Yealering a $40–50/ha return on investment was predicted, although establishment costs were higher there. Gains from saltbush could be up to $100/ha in the difficult 2006 season, for which results are yet to be analysed fully.

• *Continued next page* >

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"But this economic modelling does not tell the full story," she commented. "MIDAS analysis does not capture the additional buffering value of saltbush in a bad year, its value in risk management, source of extra crude protein, vitamins and minerals for stock, and environmental benefits such as greater water use and enhancement of plant diversity. This was certainly highlighted in 2006."

Saltbush occupied only about 11% of the land area but contributed most to landscape function including greater water use. Another bonus was visual amenity, with those saltbush paddocks being a sight for sore eyes compared with bare ground!

Research teams from all four *SGSL* research sites are preparing final reports from this very successful program. The results will be submitted for publication in scientific journals and *Focus on Salt* will provide summaries in future editions.

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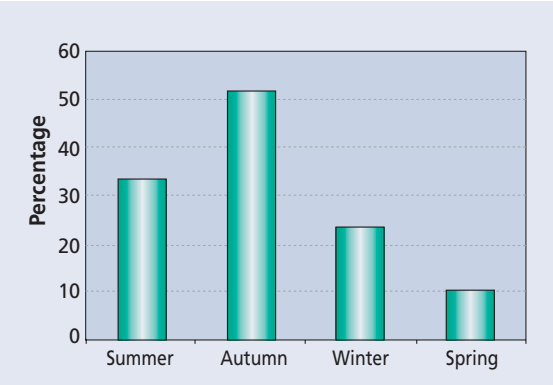

Figure 1. Percentage of saltbush in diet at Lake Grace, 2006

Best science for best NRM

By Kevin Goss

The Australian Government recently announced its continued investment in natural resources management, and that new programs will be "based on good science".

The renewed investment will be welcome as is the commitment to "good science", an issue of acute interest to the CRC Salinity, as we conservatively estimate that program changes based on the scientific output of this CRC alone will give an additional $355 million benefit.

Does the Minister's announcement mean a more rigorous approach to investment of public funds, which the CRC Salinity has been advocating? That one of the CRC's key messages — *viz.* there are not yet sufficiently profitable, sustainable land-use options for much of the agricultural regions — has been accepted? That the regional model for planning and implementing NRM and sustainable agriculture, will have the flexibility to invest in R&D where this is the best option?

The CRC Salinity can inform a more accountable national program, and recent surveys have confirmed strong support for the CRC to fill a vacuum on salinity knowledge generation.

The proposed Future Farm Industries CRC, if successful in the current funding round, will build on this and extend R&D application to enable more effective natural resource management through:

- Ongoing investment in more profitable and sustainable options for farmers
- New farming systems, including potential new woody crop industries, based on 'profitable perennials'
- Better planning tools that integrate catchment modelling, economic analysis, community input and policy options for investment decisions
- Improved performance and reliability of these new options, systems, industries and tools — ranging from higher performance perennial plant cultivars and species, to cost reduction for plant establishment and product processing
- Better understanding of the processes at work, the hazards and market prospects, and more comprehensive data for decision-making.

With climate change and drought in the headlines there has been commentary about retiring land from agriculture, and other radical changes. But these arguments offer no practical path to improved natural resource management and are at worst naïve.

Contrast this with the collaborative R&D project *Enrich*[1], which identifies and adapts fodder shrubs (including domestication of Australian native species) for new livestock production systems in the drier wheatbelt zone. *Enrich* will be innovative, profitable, adapted to climatic variability and poorer soils, and based on the science of:

- Screening a large number of candidate shrubs for palatability, growth and nutritive value
- Optimising the interactions between shrubs and traditional pasture plants for mixed grazing systems
- Identifying and manipulating plant compounds that influence sheep grazing behaviour, improve digestive efficiency and offer 'self-medication'
- Integrating the livestock component with the dominant cropping enterprise.

This will be complemented by other CRC research on seed biology, facilitating direct seeding to drive down establishment costs.

Enrich will offer a practical and profitable option for change, whereby land can be converted to more sustainable use, with farmers continuing to adjust through farm sales and amalgamations.

Good science based on CRC Salinity's R&D will contribute in other ways too:

- Research into novel technology is reducing the cost of establishing productive saltland pastures
- Up to ten prospective perennial pasture cultivars and species have been identified and when fully commercialised will add $15–50/ha to net returns
- We have identified integrated water harvesting and mobile harvesting/chipping as two critical areas for R&D if woody crop production is to be viable.

Significantly, current policies and programs subsidise farmers for these plantings. Yet this investment could be better targeted to R&D that drives technological change, reduces costs and produces profitable options for farmers. In this way good science will give better outcomes.

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[1] Initiated by the CRC Salinity and jointly funded with Meat & Livestock Australia, Australian Wool Innovation and the Joint Venture Agro-forestry Program (Rural Industries R&D Corporation)

Better drainage or surface cover needed to beat salt

By Georgina Wilson

Surface drainage that completely empties any hollows and maintenance of year-round complete pasture cover are the keys to reducing salinity, the most recent new analysis of surface salinity on a large paddock in the Great Southern Region of Western Australia is indicating.

CRC Salinity researcher Greg Hamilton (Department of Agriculture and Food), whose research is supported by the GRDC, has compared the effectiveness of raised beds and other soil management treatments over cropping land plus grazed and ungrazed pasture in the reclamation of saline and waterlogging-prone land at Woodanilling. The experimental paddock has been farmed in partnership with the property owner, Russel Thomson.

Greg has analysed in detail the factors affecting salinity on a flat valley floor, such as surface drainage, soil texture, land-use practice and soil management treatments, combined with annual EM38 surveys of the salt content in the top 75 cm of soil.

This analysis has shown that where surface drainage was efficient soil salinity dropped by up to 34 per cent from 2002 to 2006. However, where surface drainage was less than perfect over these four years, salinity remained constant. Where surface water accumulated because of poor surface drainage, the salinity increased.

Highlights

- Where surface drainage was efficient soil salinity dropped by up to 34 per cent
- Leaching re-establishes a new equilibrium salt distribution in the soil that effectively entombs the salt.

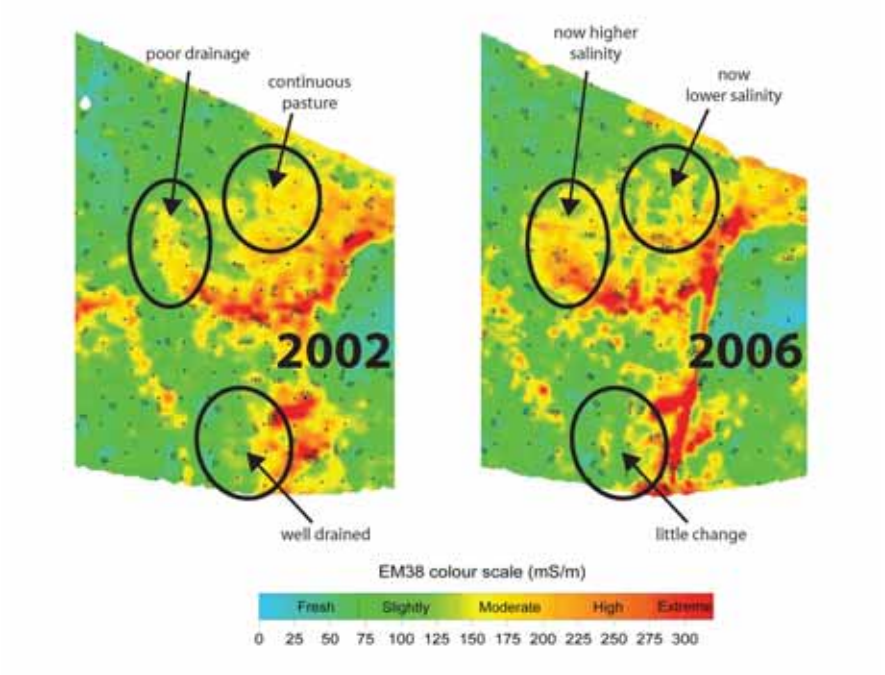

Figure 1. EM38 survey maps showing substantial salinity changes in the areas circled

"Wherever water ponded, surface salinity increased by between 7 and 36%, irrespective of whether the area was cropped or grazed," Greg commented.

"The relative effectiveness of the furrows and drains overwhelmed the effect of the different soil management treatments on salinity including raised beds," he said. "However, there was a trend for greater yields from raised beds compared with no-till beds and normal (or control) seedbeds.

"The exception to this conclusion was an area of flat, poorly drained land where the waterlogging and salinity made it too risky for cropping. A good pasture sward was maintained on this (ungrazed) area over the four years, and salinity there fell by up to 30%."

Figure 1 shows that changes in salinity from 2002 to 2006 were not uniform, apparently because they were affected by surface drainage efficiency and plant cover. Areas at the top and bottom of the maps show obvious reductions in salinity. Areas in the centre of the map, which were grazed pasture, increased in salinity.

Mr Hamilton said the lower salinity in the ungrazed area appeared to be related to the complete pasture cover minimising evaporation from the soil surface, while allowing leaching to move salt to the base of the root zone.

"Leaching re-establishes a new equilibrium salt distribution in the soil that effectively entombs the salt. Such distributions replicate those that existed before clearing, but at a shallower depth," he said.

Reclaiming saltland with pastures requires the area to be grazed very carefully or not at all, and its growth used for one or two hay cuts during spring.

This work is indicating the time required to reduce the EC in the top 75 cm of soil from about 1,000 mS/m to a 'non-saline' amount of 250 mS/m could take between four and ten years, even when surface drainage and soil management treatments are appropriate and well implemented.

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The quest for salt-tolerant wheat

Successful breeding of salt-tolerant wheat in Australia was never going to be simple — largely because the locations in which salinity is a major problem are usually low in the landscape making waterlogging a companion constraint.

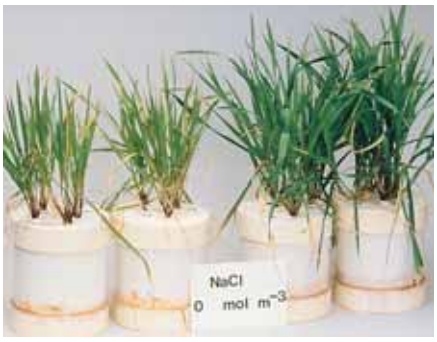
Thus, a successful breeding effort to deliver salinity tolerance alone could mean a wheat crop survives the salinity, only to be killed or have yield reduced by waterlogging. The need for dual tolerances to these stresses is emphasised by knowledge that plants are generally more sensitive to salinity when subject to waterlogging stress.

Understanding this Australian context to salinity has been fundamental to the choice of breeding approach undertaken by Dr Tim Colmer (The University of WA) and his CRC Salinity team which includes contributions from CSIRO and The University of Adelaide, along with international support and collaboration from the Swedish University of Agricultural Sciences and funding from the GRDC.

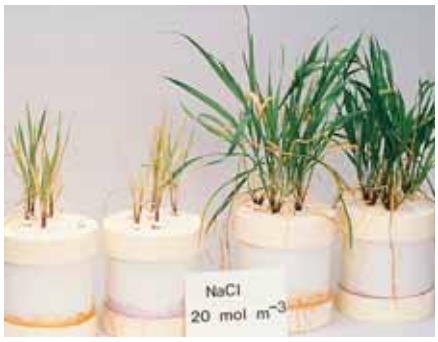
They have chosen to introduce both salt and waterlogging tolerance by crossing wheat to wild relatives with these characteristics strongly expressed. Using existing collections of such wild plants, provided by the Swedish partner Dr Roland von Bothmer, it became clear that wild barleygrasses in general and sea barleygrass (*Hordeum marinum)* in particular had good combined tolerance of salinity and waterlogging. *S*ea barleygrass has been chosen as the source of the exotic genes needed to enhance the tolerances of conventional wheat. This is consistent with its preferred habitat, saline marsh land.

The choice of sea barleygrass has provided an additional opportunity in the project. The species has become widely naturalised on salt-affected land and around salt scalds in Australia. As a direct result, a comprehensive collection has been made and subsequently screened to identify the best sources of salinity and waterlogging tolerance for future crossing programs.

Interspecific crossing involves the combination of the hexaploid bread wheat (chromosome number 42) with the diploid sea barleygrass (14 chromosomes) to produce an amphiploid (56 chromosomes). This is a challenging exercise and has largely been successful because of the skills and experience of Dr Rafiq Islam from The University of Adelaide. Not only has he been able to make these crosses with the wheat variety Chinese Spring, which is known for its suitability in such intervention, but also with adapted Australian wheat cultivars such as Westonia (WA), Sunstate (NSW and Qld), Yitpe (Mallee and SA) and Tamaroi (durum).



Waterlogged (l) and drained wheat with no salinity



Waterlogged (l) and drained wheat at 4% seawater

Photos: S Eyres

Sea barleygrass (l), the amphiploid and wheat

A way forward

Testing of the amphiploid products of crossing has been encouraging with the new plants being intermediate between wheat and sea barleygrass in tolerance of both salinity and waterlogging. The project is now in a position to test the stress response of these plants to field levels of salinity and waterlogging.

The project has two future pathways. The first opportunity is to create an amphiploid cultivar, which could be achieved in a relitavely short time-frame but which would produce a feed grade grain product. Feedback from producers supports this approach, given the lack of current crop production options for salt-affected land. Economic analysis conducted by CRC Salinity also supports the conclusion that this would be a profitable option for farmers with areas of mild salinity.

A second feasible but longer term breeding pathway would generate wheat cultivars of bread quality. This initially requires the production of seven addition lines (44 chromosomes) which contain all the chromosomes from bread wheat but only one chromosome from the sea barleygrass as a means of locating the source of waterlogging and salinity tolerance. Work to date has produced five of the seven required addition lines. Recombinant lines, with small segments of the sea barleygrass chromosomes introgressed into wheat, then need to be produced. A similar approach has been used to introduce new sources of disease resistance into wheat, so this path is feasible, but additional breeding work is needed to combine traits retaining both the salt and waterlogging tolerance.

Even if waterlogging tolerance alone is enhanced, this would be beneficial to wheat production on (non-saline) soils prone to waterlogging, a wide-spread problem across southern Australia in years of 'normal' rainfall.

The multi-disciplinary team within CRC Salinity has made rapid progress in demonstrating the potential of the proposed breeding approach and hence the prospect of delivering salinity tolerance in cultivars that will tolerate the stress as presented in the Australian context.

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Pasta, with the salt built in

Durum wheat, the premium grain for pasta making — Australia exports 200,000 tonnes annually to Italy — is a relatively minor crop compared with bread wheat, but can bring a higher return to successful growers. However, durum's attractiveness to Australian grain growers is partly limited by its sensitivity to salinity.

Bread wheat is more tolerant of salt because it has three genomes compared with durum's two, and it is the third genome that carries much of bread wheat's genetic material for salt tolerance.

To overcome this problem, Dr Rana Munns (CSIRO Plant Industry) has been looking for alternative sources of salt tolerance in the durum wheat.

The project achieved a milestone recently, isolating two genes for salt exclusion from a wheat ancestor that each function in different parts of the plant.

The first gene works by excluding salt from the plant roots while the second excludes it from the leaves. By using molecular markers to select for the two genes, the team could breed durum wheats as tolerant of salt as bread wheats.

Photo: CSIRO

Rana Munns at CSIRO Plant Industry glasshouse, Canberra

An important part of the work was the field trials, conducted with durum breeders Dr Ray Hare (NSW DPI) and Dr Tony Rathjen (The University of Adelaide). Initial trials showed the new wheats yielded better on saline soil, but still suffered a yield penalty compared with non-saline conditions. Evidently one of the genes for salt exclusion carried a 'linkage drag'.

With further research the linkage drag was found to be associated with other linked genes brought from a wild relative that was the original donor of the exclusion genes. Plant breeders at the CSIRO have managed to overcome this problem and the latest wheats should perform well in terms of both yield and salt tolerance.

A second part of the project has been to use the molecular markers to improve salt tolerance in bread wheat and, though results are preliminary, there are encouraging signs here as well. Plant breeding is a long and complex process however and commercial varieties of both these wheats are several years away.

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Salt — can wheat take it?

CRC Salinity researchers Dr Tim Colmer (The University of WA) and Dr Rana Munns (CSIRO Plant Industry), along with Professor Tim Flowers (University of Sussex) have recently reviewed existing knowledge of the differences in salt tolerance of the Triticeae tribe of grasses[1]. This review identified the potential of wild species to improve salt tolerance in wheat, there being several sources of enhanced Na^+ 'exclusion' and higher salt tolerance, both within close and more distant relatives.

The review found that 'although introgression of traits from closer relatives is easier, it is the more distant relatives, such as the halophytes (e.g. tall wheatgrass and sea barleygrass), that might ultimately provide most opportunity for substantial gains in salt tolerance.'

Research has shown that many of these species can be hybridised with wheat, and in some cases the progeny does indeed display enhanced salt tolerance, due to an improved capacity to exclude Na^+, compared with the wheat parent. However, yields are still severely reduced when salinity levels reach about one third that of seawater.

Salt tolerance arises from traits such as Na^+ 'exclusion' and tissue tolerance, which are in turn each influenced by several genes located on different chromosomes. So a significant improvement in tolerance might be expected if researchers could 'identify the underlying mechanisms' and then 'pyramid the controlling genes for traits that could act additively, or even synergistically'.

Photo: E Collis

Dr Tim Colmer

Combining a number of traits from genotypes will be a significant challenge for researchers, more so as the genetic distance increases between donor parents. However, improvements in knowledge and techniques in genetics, including molecular and transgenic approaches, together with identification of the physiological mechanisms and genes involved, should enhance our capacity ultimately to breed crops with improved salt tolerance.

[1]Colmer TD, Flowers TJ , Munns R (2006) *Use of wild relatives to improve salt tolerance in wheat*, Journal of Experimental Botany 57: 5, 1059–1078, Plants and Salinity Special Issue

Finding genes to toughen plants

Along with drought, poor soil conditions (such as salinity) are the most significant factors limiting the yield of cereal crops in Australia, highlighting the importance of research to improve the tolerance of crops to these harsh environmental conditions.

Scientists at the Australian Centre for Plant Functional Genomics (ACPFG) are researching the genetic make-up of wheat and barley, for the direct benefit to cereal breeding programs which now face increasing challenges from the changing environment.

Professor Mark Tester leads research that aims to explain the molecular mechanisms that enable certain plants to thrive in sub-optimal soil conditions, such as high salinity — where excess accumulation of sodium in the leaves limits growth.

One of the applied outputs of this program will be to modify crop plants in order to increase their productivity on saline soils. With the current focus on salinity tolerance, the solutes being studied are Na^+, Cl^- and boric acid, complemented by work with Ca^{2+}, increasing concentrations of which usually ameliorate sodium toxicity.

Using techniques similar to those employed by scientists working on the human genome project, such as 'functional genomics' (the investigation of the functions of genes), the ACPFG team plans to identify the genes that help make salt-tolerant plants salt tolerant. The approach is then to move these genes into the less tolerant commercial crops. Tolerance genes are being sought in different varieties of wheat and barley, in the wild relatives of these crop plants, and even in 'extremophiles', such as plants that will grow in salty swamps and on the cliffs of Antarctica.

Photo: ACPFG

Mark Tester, Federation Fellow, Australian Centre for Plant Functional Genomics

Currently, the movement of genes into the commercial plants is achieved through conventional breeding techniques which are being accelerated using molecular markers. These markers are bits of DNA that can easily be identified and used by plant breeders to 'chase' the tolerance genes from plant to plant through a breeding program.

The genes can also be moved using new genetic manipulation techniques, but this approach will not be deployed commercially until there is greater acceptance of the technology by the general public.

The ACPFG has a number of strategic links with wheat and barley breeding programs and with other major research organisations. These links will serve to increase the efficiency with which enhanced cereal lines are delivered to farmers throughout Australia and internationally.

The ACPFG is a major initiative of the Australian Research Council and the Grains Research and Development Corporation, with significant funding also from the South Australian State Government. The majority of scientists are based at the Waite Campus of The University of Adelaide, research also being carried out at nodes in Victoria and in Queensland.

Future editions of *Focus on Salt* will feature different aspects of the ACPFG's research on salinity.

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Knowledge 'on sale' at the bazaar

'Marketing' research outcomes to willing end-users and other stakeholders can be every bit as important as the research itself. If the research is never utilised it has been of academic value only.

A recent national workshop for regional natural resource managers recognised this with an innovative and successful Knowledge Bazaar. Created and managed by Kate Andrews and her team from Land & Water Australia, this aimed not to swamp NRM advisers with yet more information but to provide a navigational aid for lost souls.

The success of this event relied firstly upon the knowledge providers thinking carefully about what they had that would be of real value to the 'customer' and how to make it relevant and accessible. They had then to consider which other knowledge providers (present at the Bazaar) could be brought into the loop to add further value to their products.

For their part, the 'customers' looked over the providers and their wares, then signed on to a mini tour that took them to the key sources of knowledge where all was revealed.

Photo: N Hart

Hungry NRM knowledge consumers at the Bazaar

As a well focused and truly interactive event with great networking opportunities this was a brave venture. It worked well and has the potential to be an excellent link between researcher providers, research funders, and research users.

Greener grasses for severe salt

By Matt Crosbie

Tall wheatgrass (*Elytrigia elongatum*) and puccinellia (*Puccinellia ciliata*) have long been the mainstays for revegetating salinity discharge areas, particularly in the eastern States and South Australia, but work by the CRC Salinity is now focussing on grasses which exhibit even higher salt tolerance.

Dr Mary-Jane Rogers (DPI Victoria) and colleagues have already screened a range of legumes for salinity and waterlogging tolerance (see *Focus on Salt* #35), and the evaluation of grass species is a continuation of the CRC Salintiy project *Developing forage options to stabilise and regenerate saline environments*.

"Grasses tend to be more salt tolerant than legume species and the salinity levels being used in this research are twice as high as those used for the legume evaluation," Dr Rogers said.

"On the native grass side, seed and vegetative material were collected from salt-tolerant natives during the 2005/06 summer, and we are currently evaluating this material after it was multiplied under the direction of Steve Hughes at the Genetic Resource Centre in Adelaide.

"So far we have evaluated the salt tolerance levels of around forty species of introduced and native grass species, along with nutritive values and tissue ion measurements undertaken by The University of WA and CSIRO in Perth."

Highlights

- The native grass, rat's-tail couch, has similar salt tolerance to a selected accession of puccinellia
- A range of grasses has been found with higher salt tolerance than tall wheatgrass.

Photo: D Cornwall

Evaluation of the salt tolerance of 18 Australian native grasses that propagate vegetatively, including *Sporobolus, Poa, Distichlis, Zoysia* spp.

The trial has already found a native grass, *Sporobolus mitchellii* (rat's-tail couch), with a similar tolerance of high salinity to a selected accession of puccinellia.

A range of other grasses has been found which, while not as tolerant as puccinellia, are more tolerant of salinity than tall wheatgrass.

While overall productivity in some of these species may be lower than that of tall wheatgrass or puccinellia, the aim in this research is to identify species that combine productivity with high salt tolerance.

"CRC colleagues Andy Craig and Phil Nichols are now evaluating several of these species in field experiments in South Australia and WA respectively," Dr Rogers said.

In the future, it is also hoped the waterlogging tolerance of these species will be studied by Dr Tim Colmer at UWA.

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Salt tolerance of trial grasses

Species	Shoot dry weight (as a percentage of control) 0 dS/m	24 dS/m	Salt tolerance ranking*
Agropyron cristatum	100	58	Moderate
Agropyron desertorum	100	66	Moderate
Festuca arundinaceae	100	39	Sensitive
Puccinellia ciliata selected accession	100	82	Tolerant
Elytrigia elongatum	100	50	Intermediate
Cynodon dactylon	100	74	Intermediate
Distichlis distichophylla	100	55	Intermediate
Paspalum distichum	100	36	Sensitive
Paspalum vaginatum	100	64	Intermediate
Sporobolus mitchellii	100	84	Tolerant

* Tolerant-shoot DM>80% of control, Intermediate-shoot DM 50–80% of control, Sensitive-shoot DM <50% of control

Multi-scale mapping for better salinity management

By Greg Lawrence

A multi-scale mapping program by the CRC for Landscape Environments and Mineral Exploration (CRC LEME) in the Bet Bet catchment is helping create more effective salinity management strategies by improving the region's conceptual hydrological models and calibrating its salt-balance models.

In North Central Victoria, the Bet Bet catchment is mostly an upland area consisting of local and intermediate scale groundwater flow systems (GFSs). As part of the study, a series of thematic maps were compiled showing detailed distribution of soils, regolith, rock types and bedrock structure (see *Focus on Salt* #37). At a broad scale, these themes together with hydrological data were used to identify major hydrological regions or groundwater flow system associations. These were used to divide the landscape into regions with similar regolith, soil, bedrock, landform and salinity characteristics. For a whole-of-catchment perspective, this classification identified regions that require different salinity management approaches.

Within these regions, individual units, the fundamental building blocks that make up the flow system, were delineated (see Figure 1A). These units, together with conceptual models, show the inter-relationships between regolith and soil type and thickness, slope angle distribution, landscape position, geology, hydrological (including salinity) and geomorphological process (both present day and palaeo-processes). This information allows landscape areas to be identified for remedial implementation strategies.

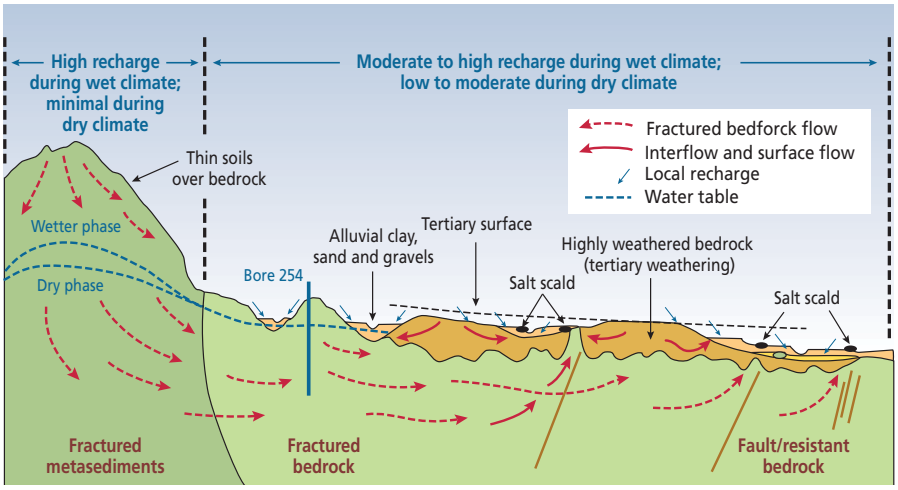

Figure 2. Conceptual models for the Lexton area showing nested flow systems

Lexton area — refining the conceptual framework

A high proportion of salinised land occurs on the western side of the Bet Bet Creek. Below the Ben More Range break of slope (see Figure 1B), the salt-affected tributary streams have a gentle gradient and are commonly incised up to five metres. They possess broad alluvial terraces bounded by low ridges or spurs, some of which are capped by thin remnants of old alluvial gravels. The landscape indicates previous periods of impeded drainage and salt accumulation and it is probable that salinity occurred naturally in this area in the geologic past.

LEME researchers John Wilford (Geoscience Australia) and Mark Reid and Dr Craig Beverly (DPI Victoria) said assessment of the geology and hydrogeology, using the multi-disciplinary mapping approach, has revealed that the salinity processes in the Lexton area are historically and spatially quite complex.

Figure 1A. Bet Bet catchment divided into major GFS associations

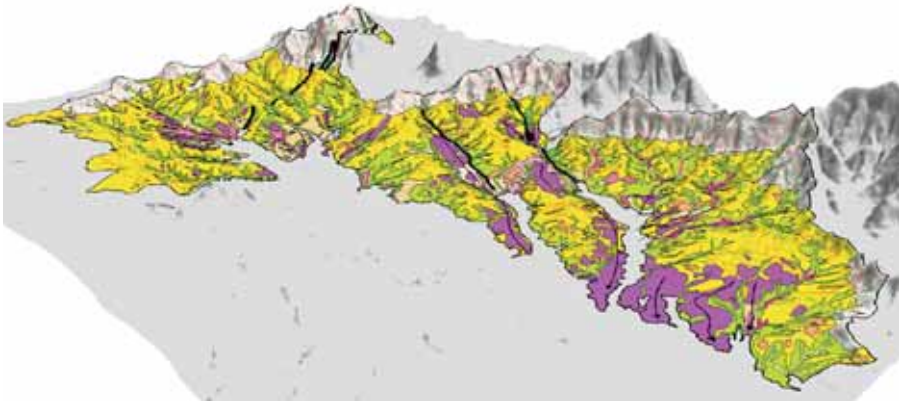

Figure 1B. Individual components (e.g. landform, soil, regolith and bedrock attributes) that make up the GFS near the township of Lexton

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"Previous modelling in the area focused largely on describing processes in the weathered, fractured meta-sedimentary bedrock to explain salinity occurrence," John Wilford said.

"However, in addition to the bedrock system, our work has shown that unconsolidated alluvial deposits form a thin, but hydrologically important mantle over a significant proportion of the lower landscape around the Bet Bet headwaters.

"These deposits contain high salt stores and are, along with the bedrock, an integral part of the salinity process for this sub-catchment. In the lower landscape, they form the upper part of a nested GFS with the weathered, fractured bedrock at its base. Our work has also added to the understanding of recharge and groundwater flow in the bedrock system itself."

Several groundwater flow processes may be active in the Bet Bet headwaters area (see Figure 2). In addition to the previously recognised deeper-seated flow in the fractured bedrock, two other flow processes are considered significant: (i) local groundwater flow within the shallow alluvial sediments of the Bet Bet headwaters; and (ii) lateral flow along the B horizon surface of duplex soils found on weathered bedrock areas in the lower landscape. In the current dry climate pattern, groundwater processes play a much reduced role in the salinity process.

Hydrographs show groundwater levels in bedrock across the Lexton area have declined considerably since 1996, as much as eight metres in the highest parts of the landscape. Recharge has been minimal in these areas, and low to moderate in the alluvial sediments and exposed bedrock of the lower parts of the landscape.

Despite the considerably lower bedrock groundwater levels in the higher parts of the landscape, water tables in the lower, prone parts continue to remain relatively high by virtue of seasonal 'topping up' caused by local, shallow processes. In most years, relatively high salt loads continue to be generated, possibly exacerbated by a bedrock structure control near the confluence of the Bet Bet headwaters, restricting groundwater flow, thus minimising seasonal decline of water tables in the salt-affected areas.

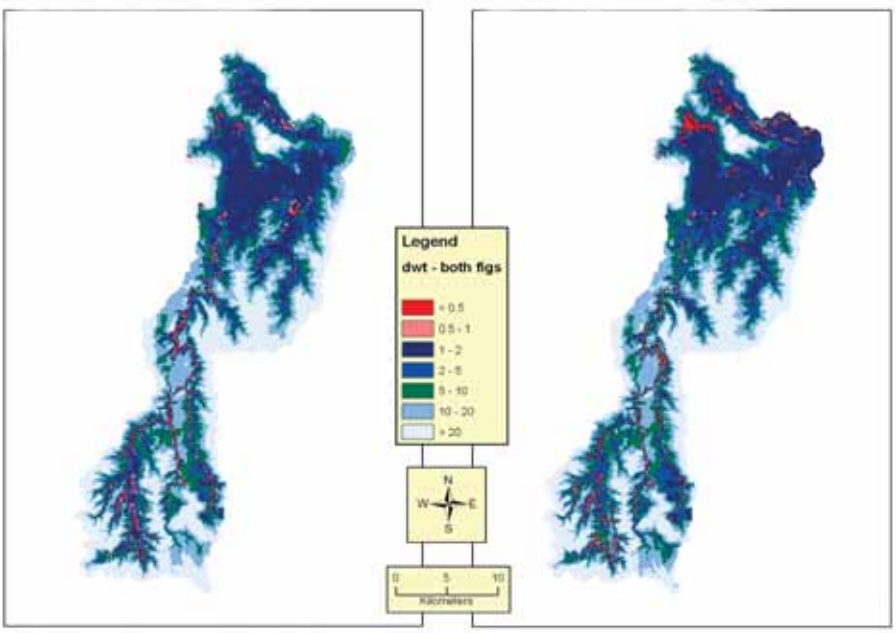

Figure 3. Simulated depth to water table based on the original broad scale (l) and revised LEME (r) regolith and bedrock information

The model shows the whole landscape leaks but the landscape component contributions to the water table vary significantly depending on climate pattern, soil type, geology and water table depth.

"For example, during wet climatic phases such as in the 1970s and 80s, high rates of recharge occurred on cleared crests and upper slopes generating high bedrock pressures which substantially added to land salinisation and salt export," John Wilford said.

"However during dry climatic phases, recharge was confined mainly to the lower landscape components. This situation can perpetuate the salinity problem if groundwater outflow is restricted, and if there is inadequate treatment of salt-affected and surrounding lower slope areas."

Building robust hydrological models

To assess the impact of the more detailed spatial and conceptual hydrologeological models, finer scale landform, regolith and bedrock information was integrated into a three-dimensional modelling framework (Catchment Analysis Tools or CAT). In general terms, the CAT is a series of farming system models linked to a suite of groundwater models. CAT is capable of simulating soil, water and plant interactions, and can evaluate the likely impact of landscape intervention on water yield, water flow regimes, salinity, vegetative response, crop yields, erosion and groundwater dynamics.

Two CAT models were developed to evaluate the improved conceptual understanding of salinity processes within the Bet Bet catchment. One model was based on the pre-existing broad scale spatial data layers; the other used more detailed soil and regolith input data developed by the CRC Salinity and the joint CRC LEME, Murray-Darling Basin Commission and the Victorian Department of Primary Industries project. In both cases, the datasets were incorporated into a four-layer, fully distributed groundwater

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model, which determined the land-use impact change on groundwater and salinity mobilisation in different catchment areas. With the exception of the revised data layers, all other model parameters remained consistent.

The CAT models were calibrated based on matching the time-varying groundwater bore responses and stream gauge information. Comparing measured and predicted depth to water table values indicated that incorporation of the revised landform, regolith and bedrock information reduced the deviation between mapped and simulated discharge zones from 18 per cent to 6%. Figure 3 compares the simulated depth to water table based on the broad scale (original) and revised (CRC LEME) regolith and bedrock information.

Catchment modelling based on the revised landform, regolith and bedrock data sets has reduced the error between measured and simulated time-varying, within-catchment salt load from 34% to 12%. Furthermore, within-catchment stream gauge measurements indicate that simulation results based on the revised spatial data layers better identify the location of zones contributing large salt loads (see Figure 4).

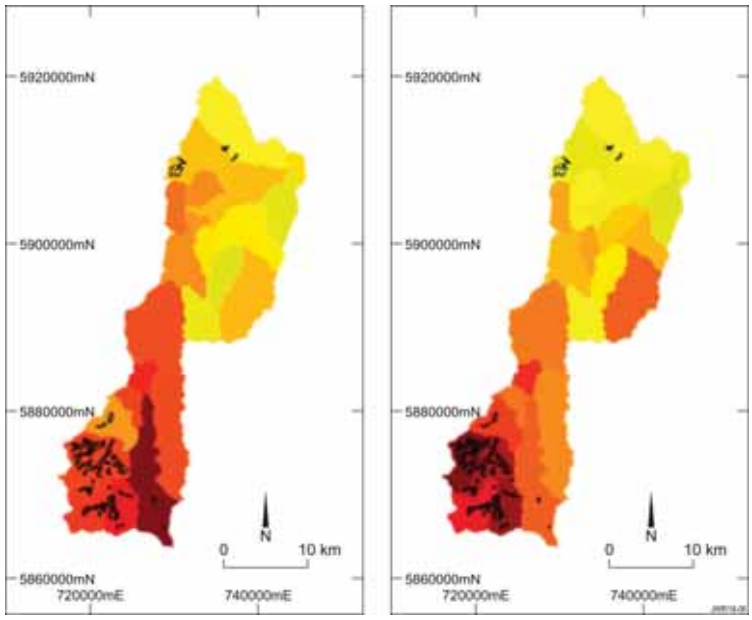

Figure 4. Simulated salt export rates (dark=high, light=low) for discrete zones based on the broad scale (l) and revised (r) regolith and bedrock information

"Thus, the more detailed mapping methodology and conceptual models underpinning the revised data sets have resulted in the development of more robust hydrological models," John Wilford said.

"This in turn has led to more cost-effective intervention strategies to meet environmental objectives and salinity management options."

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Can you afford to be without it?

Both the hard-copy and the CD-ROM of Land & Water Australia's update of the National Dryland Salinity Program communication products are now available, free of charge, from Canprint at http://www.lwa.gov.au/products.asp or Freecall 1800 776 616.

The hard-copy (Product Code PR061217) provides a snapshot of research progress since 2003, under the headings:

- Extent — what have we learned since the National Land and Water Resources Audit
- Causes — further development in understanding groundwater flow systems and other mechanisms leading to salinity
- Impacts — developments in regional planning based largely on threats to assets
- The Next Steps — strategic planning, integration, plant-based and engineering approaches.

This review cites over 100 recent relevant publications that are all available on the CD-ROM (Product Code EC061181).

This NDSP 2006 Update is the only compendium of salinity research in Australia.

800,000 saltbush seedlings in the Avon

One hundred farmers received a Saltland Pastures Association (SPA) incentive payment to grow saltbush-based pastures this year in the Avon catchment — a 120,000 square kilometre catchment with about half of all salt-affected land across Australia.

This resulted in almost 800,000 saltbush seedlings planted with a further 180 km of direct seeding.

Priority went to first time growers, with the aim of reducing the often expensive establishment costs of saltbush-based pastures.

Participation is well spread across the region, most shires having at least one farmer involved. The scheme subsidises landholders to grow up to 10,000 saltbush seedlings, or up to 10 ha of direct seeded saltland pasture.

All participating farmers received on-ground advice and support from their local Grower Support Network (GSN) adviser, set up by SPA to address the lack of saltland pasture expertise in regional WA. The National Landcare Program funded the SPA to establish a network of six part-time advisers to help overcome this recognised barrier to adoption. As part of the support, the GSN advisers have each set up a local trial or demonstration based on best practice and demonstrating species comparisons.

Photo: S Phelan

GSN adviser Kristy Baker (l), with Corrigin farmer John Hewett, and ACC Project Manager Liz Kington

In 2007 SPA will fund groups rather than individuals, aiming to be more targeted in the areas supported, but still giving priority to areas of low adoption and lower rainfall (<450 mm). The project will also take more of a 'systems approach' and expand to subsidise understorey establishment and weed control.

The project is managed by SPA with WA State and Australian Government funding through the Avon Catchment Council's Valley Floor Management program.

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Saltbush cookies

Recipe courtesy Harry Lauk, DAFWA Northam for Saltland Pastures Association

Ingredients

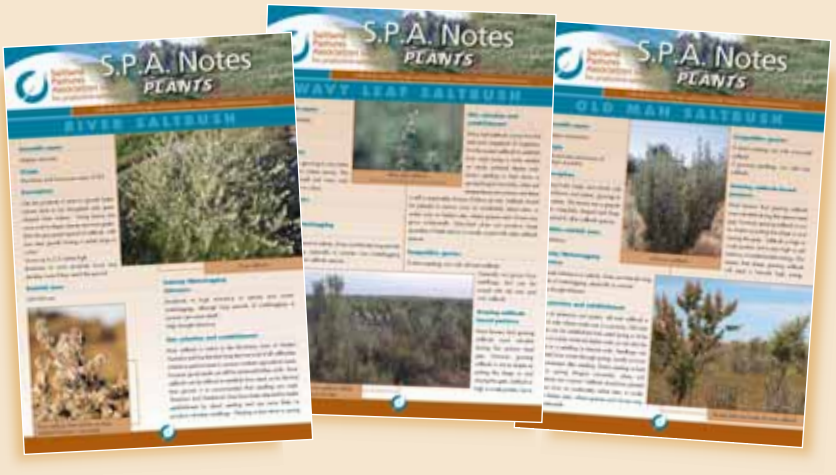
1 cup saltbush leaf
1 cup coconut
1 cup rolled oats
1/2 cup self-raising flour
1/2 cup raw sugar
1/4 cup sesame seed
1 tablespoon honey
1 egg
185 g butter

Method

- Blanch the saltbush leaves for 2 minutes to remove bitterness; rinse, then press in hot water.
- Mix dry ingredients with moist saltbush; add egg, honey, butter and mix well.
- Spoon onto greased oven tray, bake in moderate oven for 12–20 minutes.

Note

Ingredients must be added in the order above. River saltbush is recommended ahead of wavy leaf then oldman. The SPA has a series of saltbush fact sheets on its website www.crcsalinity.com.au/spa/index.htm.



New roles for fescue

By Matt Crosbie

The search is on for a drought-tolerant, summer-active tall fescue to suit the lower and less reliable summer rainfall areas of northern NSW. A tall fescue improvement program has identified a number of promising lines that display increased persistence and production compared to existing cultivars.

CRC Salinity researcher Carol Harris (NSW DPI) said the project, supported by Meat & Livestock Australia, is based around plant nurseries established in 2004 at Barraba and Inverell, which are typical of the targeted recharge areas in the 500–700 millimetre rainfall zone.

"We are comparing ninety-five accessions and cultivars from around the world with twenty cultivars available in Australia, comparing seasonal production, persistence, disease resistance, nutritive value and endophyte status."

Carol says there is a big opportunity to increase the amount of tall fescue being grown in NSW, and consequently, an opportunity to increase water-use efficiency of pastures.

Currently, she says, there is about 940,000 hectares of fescue grown, but the potential zone of adoption for this important perennial in NSW is estimated to be around 8.6 Mha. A new persistent and drought-tolerant variety will help increase the area sown to tall fescue especially on the Northern Slopes of NSW.

Photo: C Harris

Barraba trial breeding nursery (Spring 2005) producing a better fescue for the lower rainfall recharge zones of northern NSW

Tall fescue is widely adapted to a range of soil types including those with moderate levels of acidity, salinity and fertility. It is more tolerant of waterlogging than cocksfoot and more tolerant of soil acidity than phalaris.

Two types of tall fescue are grown in Australia — those that originate from temperate Europe or America which are spring/summer-active varieties, and those of Mediterranean origin which are winter active and summer dormant.

"In summer rainfall areas of NSW, such as the Northern Tablelands and Slopes, newer temperate varieties of tall fescue have been evaluated since 2001. The varieties Quantum and Dovey showed significantly higher production than the traditional Demeter and AU Triumph, while persistence over five years was comparable.

"These temperate varieties grow vigorously over spring, summer and early autumn in areas with an annual rainfall of more than 650 mm. Whereas winter growth is slow, they provide good year-round production of quality feed as they do not frost off as readily as either phalaris or cocksfoot.

"Under lower rainfall and in areas with an altitude less than 700 metres, the temperate varieties do not persist as well.

"Mediterranean varieties, on the other hand, are more drought tolerant due to their summer dormancy and have a similar winter and early spring growth pattern to phalaris.

"These varieties have extended the zone where tall fescue was traditionally grown into the summer dry areas of southern NSW and Victoria.

"However, in regions with summer rain, the Mediterranean varieties have significantly lower annual yield than the temperate types."

..... and safe endophytes

One of the most recent developments has been the incorporation of non-toxic endophytes into tall fescue cultivars to improve plant water use, tillering, pest resistance, nutrient efficiency, persistence, drought tolerance and the mobility of aluminium in roots.

Tall fescue endophyte is a fungus (*Neotyphodium coenophalium*) that lives inside the plant, forming a symbiotic relationship where the plant supplies the endophyte with nutrients and a mode of spread by the host plant's seed. Fortunately, while wild endophyte types produce harmful alkaloids, in Australia the current cultivars used are low in, or free of wild type endophytes.

"Safe endophyte tall fescue varieties are relatively new to NSW and as such, there is limited data available on their performance and persistence," Carol says.

"However, early data indicates the Mediterranean safe endophyte varieties have the potential to extend the zone of adaptation of tall fescue into lower, more marginal rainfall areas.

"Unfortunately, temperate safe endophyte varieties are not showing the same potential for improved production and persistence in high rainfall areas."

The promising accessions identified in this CRC Salinity project all have good establishment, superior persistence under severe dry conditions, consistently high production, and are endophyte free. Individual plants of these accessions were collected from the nurseries in Spring 2006 for the next phase of the breeding program at Hamilton Victoria.

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Highlights

- New cutivars should improve persistence and productivity of available fescues
- Opportunity to expand the growing zone of fescues
- Mediterranean safe endophyte varieties show promise.

Crops to grazing chops salt

By Matt Crosbie

Catchment salt output can be halved through changed management — that's the message from 13 years of data on what is probably the longest continuously maintained salinity trial in New South Wales.

Since 1993 a range of organisations including Landcare, Sydney University and NSW Department of Primary Industries has monitored a 129 hectare subcatchment on David Marsh's Boorowa district property, *Allendale*.

Photo: M Crosbie

CRC Salinity Extension Leader, John Powell (l), Landmark's David Armitage, and David Marsh at *Allendale*

Over that time David Marsh has gradually changed from annual cropping of the area to planned rotational grazing.

Prior to 1991 the area was cropped under a wheat/lupin rotation, but in response to salinity, alley farming was introduced in 1993 with belts of trees, 25 metres wide, every 75 m, and the cropping program continued.

The major change came in 1999 with the cropping program ceasing and the move to rotational grazing on perennial pastures of phalaris, cocksfoot, subclover, a small amount of lucerne and salt-tolerant grasses on the lower, saline areas.

Highlights

- Longest running salt trial in NSW
- Quantified positive impact of land-use change on salinity
- Move from annual cropping to perennial pastures dramatically reduces recharge, run-off and salt output.

"The visible signs of salinity have diminished in the past five to six years — but the problem hasn't gone away yet," David Marsh said.

"Grazing management and maintaining the perenniality of the site is fundamentally important. We aim to maintain 100 per cent groundcover all the time. Planned rotational grazing on a high density, short rotation basis allows plants to reach their potential, maximising root growth. In contrast, continuous stocking tends to keep plants small, limiting root growth and soil organic matter. Basically, with little plants you are only farming a small part of the landscape."

Adaptive management

"Running a fully stocked enterprise in a variable climate is extremely risky, if you are trying to increase groundcover. Since 1999 base stocking rates on the property have been reduced by 30% (from 12–14 to 8–10 DSE/ha), reducing the need for supplements. The 30% reduction in stocking rate leaves a buffer that can be filled with trade stock or agistment.

"Rainfall for 2006 has totalled only 220 mm to mid-November and stock numbers have been reduced to 2 DSE/ha — in June 2006 the stocking rate was 8.3 DSE/ha. By contrast, the November 2005 stocking rate was 11 DSE/ha.

"We now have no breeding stock and run wethers, with 20% of the property under woody vegetation, compared to the original 3%.

"Using the rotational grazing system, we haven't used inorganic fertiliser in the past seven years — the key is changing numbers as the season unfolds. This is very dynamic and we monitor growth rates as a guide. We are not experiencing any signs of production constraints — I keep waiting for the wheels to fall off the system, but so far everything has been fine."

"The perenniality of the system and diversity of the pastures continues to improve."

The assessment

According to NSW DPI researchers, Russell Crosbie and David Mitchell, dramatic results have occurred on the property — and the data and research show the fall in salinity is due to changes in land management, not the ongoing drought.

The analysis of data on *Allendale* has been conducted as part of the *Key Sites* project that commenced under the NSW Salinity Strategy and now has support from the National Action Plan for Salinity and Water Quality.

"Data from *Allendale* helps us to understand the impact of land-use change on water and salt movement, as well as allowing models for salinity management to be validated against actual catchment results," David Mitchell said.

"Five years after the move away from cropping and into perennial pastures, there is almost no recharge, run-off has been reduced and the salt output has halved.

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"Significantly, the research shows that these results have been achieved irrespective of the dry conditions over the past few years (see Figure 1).

"The salt output:input ratio has fallen from 22:1 to 10:1 and salt discharge per unit area has fallen from an annual 56 tonnes per square kilometre to 26 t. This is due to the reduced volume of water discharged off the site rather than a reduction in the EC of the water.

"Numerical modelling suggests the benefits of the land-use change in terms of groundwater levels will not be fully realised for several more decades."

Modelling studies of the Boorowa River catchment highlight the need for targeting high recharge, high salt export subcatchments. This subcatchment is identified as having a high salt export per unit area and high salt output:input ratio relative to the Boorowa catchment, which in turn is high relative to the Lachlan catchment at Cowra. Further land-use changes similar to those implemented in this study targeted to other high salt export subcatchments are likely to have a large cumulative effect on stream salt loads and stream flow in the Boorowa catchment.

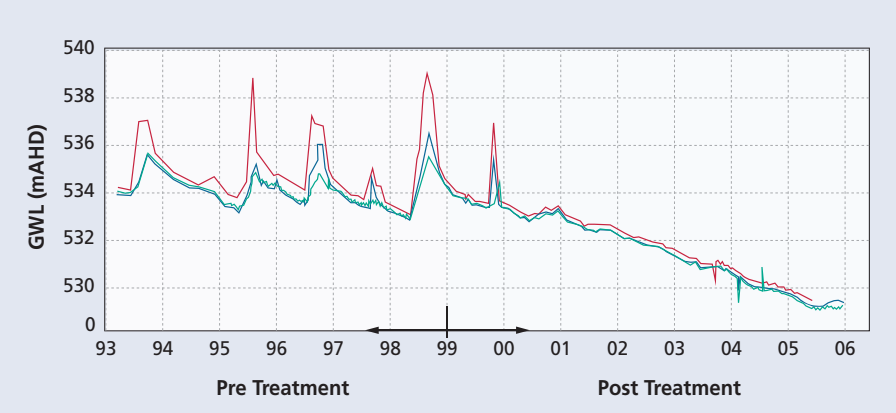

Figure 1. Water tables at three locations on *Allendale*

This research has been accepted by the international journal *Agricultural Water Management*.

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EverGraze expands the search for better pastures, livestock and catchments

EverGraze — More livestock from perennial$ has expanded with Australian Wool Innovation (AWI) joining Meat & Livestock Australia (MLA) and the CRC for Plant-based Management of Dryland Salinity as a new partner. *EverGraze* will now include native pastures and target wider NRM outcomes, with increased opportunities for farmers to be involved.

In other developments, Geoffrey Saul, formerly Site Leader for Victoria, has been appointed National Coordinator for *EverGraze*, where he will work closely with Science Leader Angela Avery and Proof Site Leaders in three states.

Three new Proof Sites will test new farming systems in large scale, intensively monitored experiments, measuring key soil, water, pasture and livestock inputs and outputs, enabling accurate modelling of the impact of farm management change on catchment outcomes and farm profits.

In the Murray (NSW) and North East Victoria region, the Proof Site will examine the effects of grazing management and fertiliser inputs on the sustainability and productivity of native pastures, and on the NRM outcomes.

In the Central West and Lachlan region in New South Wales, *EverGraze* will assess the effects of low, medium and high intensity grazing of native pasture systems on animal production and NRM outcomes such as perenniality, biodiversity, groundwater recharge and soil health.

In the Border Rivers/Gwydir and Namoi region the focus will be on determining the most appropriate proportions of native and sown pastures for different land classes. The site will also undertake research on the value of lucerne mixtures to enhance productivity and NRM outcomes, and assess the relationship between production and biodiversity and develop monitoring tools for farmers.

EverGraze is also establishing, in collaboration with local catchment authorities, a network of Supporting Sites on farms in catchments nears the Proof. These will provide livestock farmers with the opportunity to test new technologies in their own backyard at a commercial scale.

"There is great scope to develop options that are genuinely attractive to farmers and provide positive outcomes for catchments. But this goes beyond just growing more and better managed pastures. *EverGraze* is about more productive animals, lower cost of production through improved management practices, and on a feed-base that is perennial, increases biodiversity, maintains good groundcover and where appropriate reduces recharge," said Geoffrey Saul.

All groups involved in *EverGraze* will also participate in developing extension and delivery systems relevant to their area, accessing information from the network of Proof and Supporting Sites and sourcing speakers or visiting case study farms.

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Adoption — why some do, but others don't

By Bruce Munday

A great deal of research and trialling has been devoted to improved methods of land management and conservation. So it is sometimes disappointing to researchers, and policy makers and regional bodies, when sound new practices are not widely taken up by farmers.

CRC Salinity researchers Professor David Pannell (The University of WA) and colleagues have recently undertaken a multi-disciplinary review of literature[1] on the adoption of rural innovations. Their findings will be of interest to scientists and their funding sources, extension agents, policy makers, managers in government agencies, NRM bodies (such as catchment management authorities), and non-government conservation and farmer organisations.

If there is one central message from this review it might be summed up as "adoption occurs when the landholder perceives that the innovation … will enhance the achievement of their personal … economic, social and environmental goals."

By contrast, non-adoption or low adoption of sound innovations can come down to its failure to provide relative advantage or to difficulties that landholders have in trialling them.

Highlights

- Landholders adopt innovation in pursuit of personal economic, social and environmental goals
- If the burden for promoting adoption falls entirely on communication, education and persuasion, it is likely to fail.

Photo: B Munday

Landholder engagement relates to personal goals

The authors comment that the current level of adoption of innovation in Australia is far short of what will be required to arrest the landscape-scale degradation caused by issues such as dryland salinity and biodiversity loss.

They look in detail at the process of learning and experience that informs adoption decisions; the social, cultural and personal influences on adoption decisions; and then the attributes of those practices that affect the adoption of innovations.

The lessons learned from this considerable body of work, particularly when viewed through multi-disciplinary eyes, have important implications for the range of stakeholders whose charter is to bring about significant land management change in the interest of sustainability.

Implications for research

A great deal of research is very much about finding 'better' ways of doing things, and ultimately it will be judged by the extent to which stakeholders adopt these 'better ways'. To support high levels of adoption, biophysical scientists are encouraged to be conscious of the type of practices landholders adopt more readily — those with high relative advantage and high trialability

A participatory approach with landholders encourages engagement, which can lead to adoption, and this should be supported by a real awareness of what landholders are already doing and why they do it.

It is not uncommon to hear advocates of land management change say "it's all about people" and "farmers won't take it up unless it makes economic sense" — comments consistent with the review finding that biophysical scientists should look for opportunities to work closely with economists, sociologists and psychologists.

Implications for extension

The reviewers contest a conventional premise that lack of adoption implies inadequate communication. Rather than advocating a greater effort to improve communication of research 'products', they argue farmers are already deluged with information, some of which is contradictory.

For communication to really enhance extension it needs to be founded on "credibility, reliability, legitimacy, and the decision-making process."

[1] Pannell DJ, Marshall GR, Barr N, Curtis A, Vanclay F, Wilkinson R (2006) *Understanding and promoting adoption of conservation practices by rural landholders*, Australian Journal of Experimental Agriculture, 46: 1407–1424

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Ultimately the decisions of landholders will be guided by the perceived alignment of management changes with their personal goals. Given the heterogeneity of landholders and their lands, any single practice advocated is likely to attract only a limited section of the landholder spectrum.

The authors argue extension is unlikely to make a difference to adoption of practices with which landholders are already very familiar, unless it provides new skills needed to apply those practices. This means extension will have its biggest influence early in the adoption process, such as when landholders are just becoming aware of an innovation, and is unlikely to substantially lift the final level of adoption.

Not surprisingly, the review finds that sound extension employs a range of methods to accommodate a diverse audience's preferences and learning styles.

State agencies have moved further away from one-on-one extension towards group-based extension, partly for the cost savings to the provider, but also on account of the proclaimed adult-learning benefits. However, the reviewers argue that the swing from individuals to groups might now have gone too far.

Returning to the vital issue of credibility, trust and confidence influencing the likelihood of adoption, Pannell *et al*. note firstly that such reputations are slowly acquired but can be quickly lost. They argue that the recent trend of government extension providers away from "….supporting landholders in making good decisions to achieve their own goals, towards encouraging landholders to make decisions that achieve outcomes for the public good…." might diminish the real influence of the extension service.

Implications for policy and regional bodies

The authors caution against the familiar call for yet more social research to explain the lack of adoption by landholders of conservation practices. Rather, they argue for applying what is already well known, in particular, attempting to align the public's with the landholder's goals and demonstrating to landholders that the benefits of achieving these goals outweighs the costs.

If the burden for promoting adoption falls entirely on communication, education and persuasion, it is destined to fail, they argue, unless the innovation is intrinsically appealing to landholders. This means the innovations need to be 'adoptable'.

Part of the appeal of this paper is that it draws on the complementary strengths of different disciplines: "We found that many of the findings and perspectives of our separate disciplines are consistent and readily translatable across disciplinary boundaries. We discussed these findings in three broad groupings: those relating to adoption as a process of learning, those relating to characteristics of potential adopters, and those relating to characteristics of the conservation practice."

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Making lucerne pay

Farmers contemplating lucerne as a component of their cropping system now have no shortage of sound information.

Focus on Salt #38 introduced readers to the CRC Salinity's *Lucerne Prospects – Drivers for widespread adoption of lucerne for profit and salinity management*.

Here we profile a further valuable contribution to the thinking farmer's decision making: *Making Lucerne Pay – Integrating crops and lucerne on mixed farms*.

Published by the DPI Victoria and the Grains Research and Development Corporation, *Making Lucerne Pay* uses 13 successful Victorian case studies to show that perennials in cropping systems can be both practical and profitable.

These case study farmers successfully managed stock and lucerne pastures on their farms while conducting intensive and often no-till cropping operations. They saw the key advantages of lucerne as: (i) providing a profitable pasture phase; (ii) spreading risks across at least two enterprises (grain and meat and/or wool); (iii) utilising summer rainfall; (iv) reducing the rates of nitrogen fertiliser applied to crops; and (v) improved weed control.

Economic analyses showed that all farms enjoyed an increase in profitability from lucerne, ranging from 9 to 63 per cent, and averaging 35%. This arose largely from the highly-profitable livestock enterprises, with less obvious benefits from the cropping component.

Three of the farmers commented they would not be farming today but for lucerne, whilst another three indicated they are intensifying their cropping operations at the expense of lucerne.

An important aspect of lucerne in farming systems is its contribution to recharge abatement in regions affected by salinity and waterlogging. It is perhaps ironic that two significant publications on the merits of lucerne should be published in a year when rising water tables and waterlogging will affect very few farmers.

But as one threat abates another often steps into the breach, and this year many struggling crops received the 'killer blow' from widespread frosts. For many farmers the resilience of lucerne was at least some relief. In all likelihood, 2007 will be different again.

The economic analyses in both these

publications show optimum profitability of the lucerne phase comes from prime meat production. However, a resurgent wool market might shift that balance and with lucerne hay currently fetching $300/t at the farm gate there could be further bonuses ahead for farmers with lucerne.

Making Lucerne Pay can be purchased for $30 from DPI Bendigo (03 5430 4451) or online at www.grdc.com.au/bookshop/sale.htm

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SGSL bringing it all back home

By Bruce Munday

In the beginning...

The farmer

About five years ago I toured the countryside with Warren Mason, Michael Lloyd and Richard Price, talking to woolgrowers about the possibilities for a grower-initiated R&D program to improve the profitability and sustainablility of grazing salt-affected land — part of the embryonic Land, Water & Wool program.

The first message we took from growers was that they did indeed have many questions they wanted answered by research, the research should be locally relevant but capable of being shared across a network of growers, and it should be carried out by existing groups (such as producer or landcare groups).

The other unmistakable message wherever we spoke to growers was that their interest in managing saltland did not stop at profit and sustainability. There was an underlying issue of personal pride — pride in managing difficult land responsibly and turning it from an eyesore to an asset.

The scientist

A couple of months later a group of scientists gathered in Adelaide to map out a 'hard core' national research program, aimed at some of the fundamental questions around managing saltland in very different environments.

The CRC Salinity took responsibility for this research, establishing sites near Tammin and Yearlering in WA, Keith in SA, Hamilton in Victoria, and Gumble in NSW. At the same time there was real enthusiasm among researchers for the prospect of working in parallel with producer-driven projects.

Fast-forward to 2006

The rest, as they say, is history.

One hundred and twenty Producer Network sites have generated a great diversity of learnings — some of it quite esoteric and of interest mainly to a small but important group of locals. Others have uncovered facts about saltland pasture establishment, animal nutrition, and grazing systems that are sure to be of interest to anyone with saltland. Some answers have inevitably raised further questions that invite further research.

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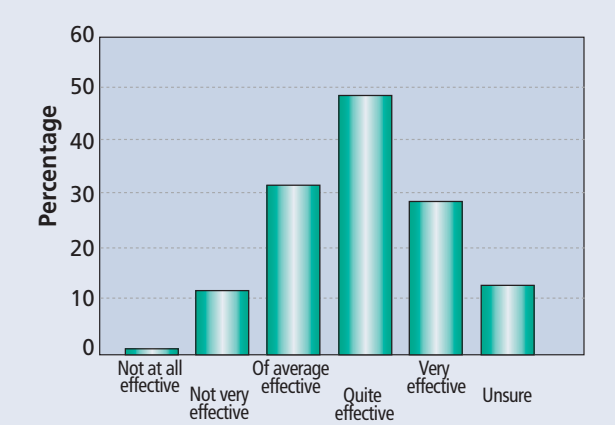

Figure 2. How effective has *SGSL* been in creating, on-farm environmental or landscape improvements from better management of saline land?

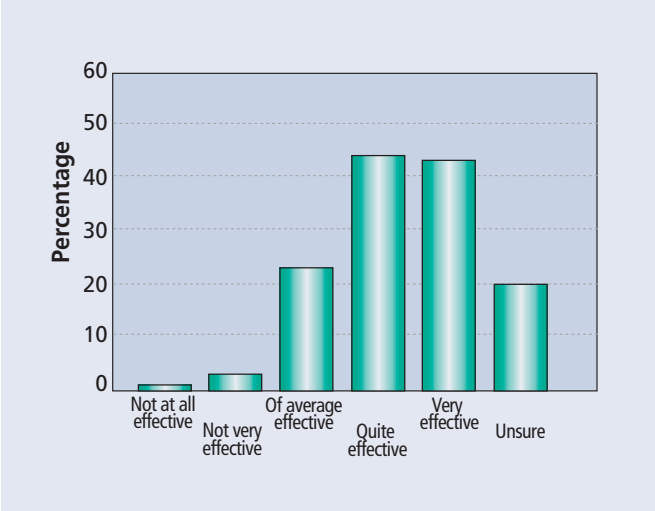

Figure 1. How effective has *SGSL* been in supporting improved social outcomes and benefits (including pride and motivation) from better management of saline land[1]?

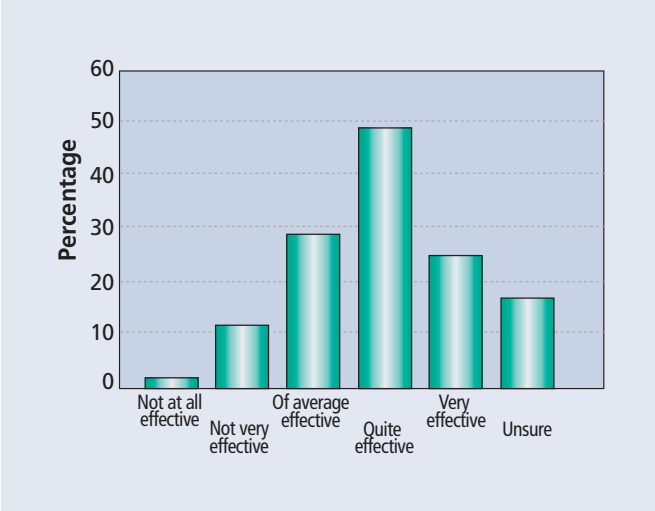

Figure 3. How effective has *SGSL* been in creating actual, on-farm improvements in productivity or economic returns from better management of saline land?

[1] The high level of 'unsure' responses largely reflects the reluctance of respondents to comment at this stage on the effectiveness of *SGSL* at the national level

• *From previous page*

The core research projects have come up with the 'hard data' and interpretation about the economics of saltland pasture; salt and water movement; biodiversity impacts; siting, establishment and performance of saltland species; and performance and use of saltland pastures.

In September this year researchers from the CRC and growers from the Producer Network gathered in Ballarat to share just how far they had come and to showcase the final products that they are developing.

Each State is developing a series of products relevant to its own stakeholders. There is a range of products including project reports, fact sheets, case studies, and manuals and in one case even a video.

The CRC's research will be submitted for publication in peer reviewed journals.

Finally there will be a national 'synthesis product' that will bring together all the key findings from *SGSL* integrated with other work on saltland pastures in Australia — this will be a major reference source for land managers and researchers working with saltland pastures.

How are we travelling so far

Recently an independent survey was undertaken of those involved in the implementation, support and management of *SGSL* and those who draw on *SGSL* information and activities to support their own role in addressing salinity issues. While the results are still being processed, three interim pieces of data are encouraging

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One size doesn't fit all

By Jo Curkpatrick

Recent research in the Eastern Dundas Tablelands of south west Victoria strikingly confirms a key message from the National Dryland Salinity Program[1] : "... the many forms of salinity expression require a corresponding diversity in response (including no response)."

Dr Jon Fawcett (DPI Victoria) has studied the development of land degradation patterns around groundwater discharge zones in this area. He finds degradation is not driven by salt concentrations resulting from water tables that have risen since European settlement and land clearing. Rather, it is more likely to be a direct result of the disturbance to the soil environment of these discharge zones.

"We looked at the information, both historical and current, and found that in the Dundas Tablelands there was no massive clearing event. To the contrary, it took from 60 to 80 years to occupy and clear the land, and the records suggest there was actually an increase in tree density for several decades as more, smaller trees regenerated after the large, older trees were felled.

"The real clearing didn't come until the 1920s through to the '50s. Furthermore, even prior to European land clearing there was documented evidence of saline areas along the region's streams."

So what caused the problem? How do you explain the severe degradation?

According to Jon Fawcett the key is the relationship between the geological structures and the groundwater flows.

"Examining the processes driving the formation of iron and saline rich scalds in groundwater discharge zones on the Tableland, we found them to be quite different to discharge sites within the Murray-Darling Basin.

"We found gravity-driven, nested groundwater flow systems, which means the groundwater at discharge sites, was coming from different depths and different periods of time. The discharge is a mixture of water from pre-clearing and post-clearing eras."

Photo: J Fawcett

Iron clogging caused by a cycle of wetting and drying within a macropore of a discharge zone

Focus on the discharge zone

"Turning to the soil and chemistry of the discharge zones we discovered in addition to salt, further problems arose from sodic soils, low pH and precipitation of iron.

"Where the discharge zone remains permanently saturated we found lower levels of degradation," says Dr Fawcett. "There the pH and salinity of the water remain relatively stable. But where water discharge is unable to continuously saturate the discharge zone, the water pH becomes highly acidic and there is a significant increase in salinity.

"The groundwater contains hydrogen sulfide (H_2S) which, in a ponded situation, dissipates to the atmosphere causing little soil degradation. However, if the H_2S reaches a soil surface unprotected by water, there follows a series of chemical reactions that can lead to degradation.

"The situation is exacerbated if the discharge site is disturbed, for example by stock trampling or by drainage. In this disturbed discharge zone, the H_2S will come into contact with iron and organic matter, with iron-rich precipitation in the soil pores and over the surface, salt accumulation and severe acidity."

The impact according to Jon Fawcett is that where these particular processes are occurring on the Dundas Tablelands, tackling the recharge zone won't cure the problem. Land clearing may have altered the seasonal flow systems operating within the regolith, which are partly responsible for the spread of salinity and erosion, but the groundwater discharge associated with the severe degradation occurred long before land clearing.

[1] Van Bueren M, and Price RJ, (2004) *Breaking Ground – Key findings from 10 Years of Australia's National Dryland Salinity Program*, Land & Water Australia, Canberra, ACT

Strawberry clover in the pink

By Matt Crosbie

Nothing is better than lucerne on country which suits it, but across big areas of the high rainfall zone of south-east Australia lucerne just isn't going to grow. And currently, there's not much choice in terms of perennial legumes — especially when white clover doesn't survive if summer rainfall is below average.

CRC Salinity researcher into perennial legumes, Pedro Evans (DPI Victoria, Hamilton Centre), believes strawberry clover (*T. fragiferum*), the biennial Alsike clover (*T. hybridum*) and a range of lotus cultivars may be the answer.

"I think strawberry clover, which has a number of commercially available varieties, has been incredibly underrated around here," Pedro says.

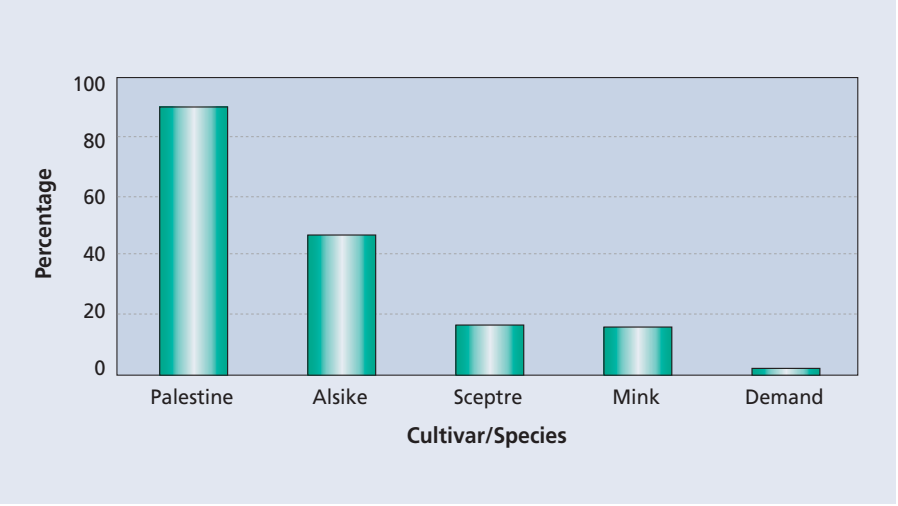

Figure 1. Persistence of five commercial perennial legumes after four years

"After four years of trials it was covering nearly 100 per cent of the ground, and the only other clover which has exhibited this type of persistence in this area is annual subclover. But strawberry clover is a perennial, so it will produce in summer if we get the occasional rain and it will be way ahead in the autumn when the 'subs' are only seedlings.

"Lucerne is widely sown, although it suffers from severe limitations, which restrict its use, including a lack of tolerance to set stocking, susceptibility to waterlogging, and sensitivity to acid soils and high aluminium levels.

Highlights

- Fifty-six perennial legumes tested for high rainfall, acid areas
- Strawberry clovers and lotus performing well in the drought
- Palestine strawberry clover highly productive and persistent.

"The species likely to be viable alternatives to lucerne in the high rainfall zones include strawberry clover in wet and mildly saline patches and the lotus species in wet and acid soils."

The trials

In a four-season trial, fifty-six perennial legumes were evaluated at Hamilton beginning with an August 2002 sowing of *Lotus corniculatus*, *L glaber*, *Medicago sativa*, *Trifolium africanum*, *T. burchelianum*, *T. fragiferum*, *T. hybridum*, *T. ochroleucon*, *T. panonicum*, *T. physodes*, *T. pratense*, *T. repens* and *T. tumens*.

Commercial cultivars used as controls were Colenso red clover, Demand white clover, Mink white clover, Palestine strawberry clover and Sceptre lucerne.

Seed was inoculated with appropriate rhizobia and fertiliser applied at 250 kg/ha of single superphosphate and 150 kg/ha of potash.

The trial was grazed intermittently with sheep for 12 months after establishment and after each dry matter assessment. The first dry matter assessment was made in August 2003.

• *Continued next page* >

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"On some discharge sites, where the system has been stabilised, we've seen native grasses, trees and biodiversity returning.

"For this part of the world, lowering the water table is not a feasible management option — the water table has 'always' been high. Managing the discharge is the key, and this is a feasible option."

This research shows the value of a multi-disciplinary approach, including landscape history, both biophysical and anthropogenic, to fully understand the impact of European settlement on degradation processes. It also highlights the importance of site specific knowledge to inform restoration strategies.

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Rainfall over the trial period was variable. While the mean annual rainfall for the site is 688 mm, the annual rainfall over the 2002–05 period was 561, 728, 728 and 541 mm. Rainfall during January-March 2003 and 2004 was above average, as was rainfall during January-February 2005.

Overall the best performances were from the strawberry clover lines, which were highly productive and persistent across seasons and years (see page 19, Figure 1). Importantly, the commercial cultivar, Palestine strawberry clover is readily available for sowing.

Alsike clover performed well in the earlier years, but has failed to perform in the current drought conditions.

The commercial white clover cultivars Mink and Demand persisted well until Spring 2005.

Lucerne declined in numbers and production throughout the trial and made little contribution to the sward after the first year.

Photo: P Evans

Strawberry clover — the great drought survivor

Autumn production (Figure 2)

Lotus corniculatus yielded more than twice that of any of the commercial lotus cultivars in autumn, suggesting it could play an important role in helping to fill the late summer-autumn feed gap. Currently the best late maturing annual legume for the area, late maturing arrowleaf clover, does not extend its growth period past early February.

Alsike clover out-produced Demand and Mink white clovers, Palestine strawberry clover and Sceptre lucerne during the autumn.

Winter production (Figure 3)

A strawberry clover and a lotus line produced around 3 t/ha of dry matter, while biennial Alsike clover out-produced the biennial control, Colenso red clover. Mink white clover and Palestine strawberry clover were the most productive commercial cultivars.

Spring production (Figure 4)

The new strawberry clover lines performed slightly better than Palestine, the commercial control, while Lotus corniculatus performed poorly, although still better than lucerne.

Demand and Mink white clovers performed well.

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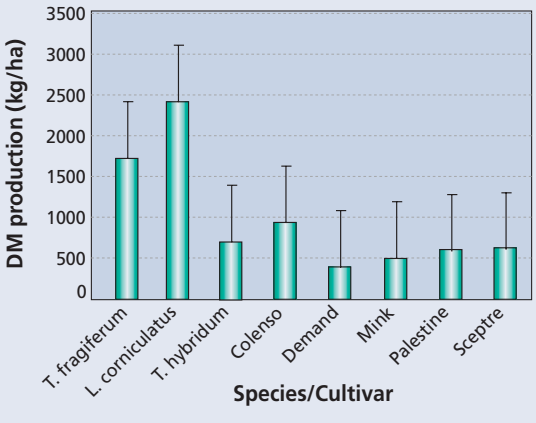

Figure 2. Autumn production

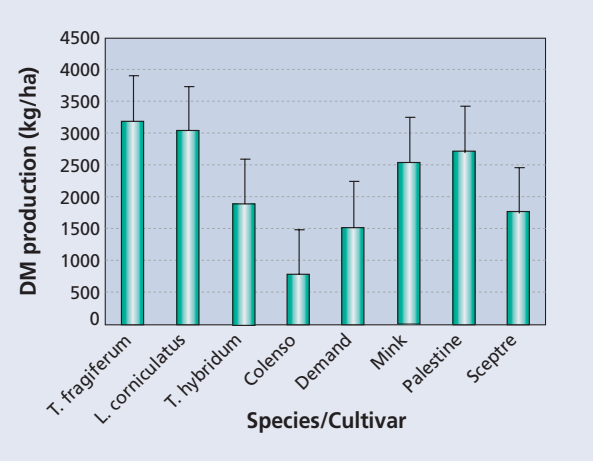

Figure 3. Winter production

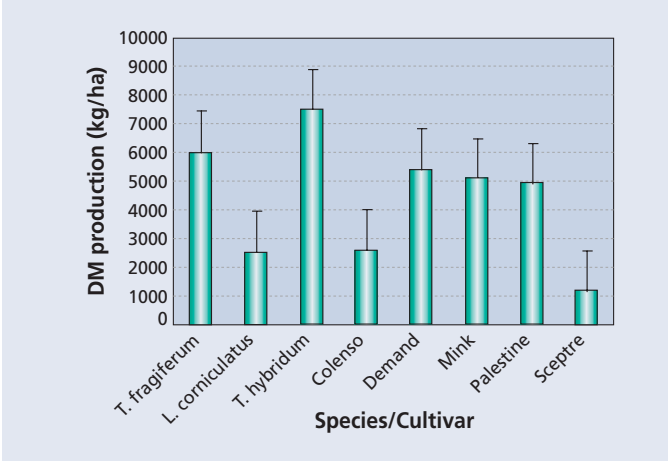

Figure 4. Spring production

Disturbing cases of native grass

In Canada, natural prairie grassland (*Stipa-Bouteloua-Agropyron* spp.) and regenerated native grassland on abandoned cultivation show considerably better water and nutrient cycling abilities than introduced pastures according to CRC Salinity researcher Dr Sean Murphy (NSW DPI, Tamworth).

These findings may have implications for managing Australian native grasslands for both productivity and water-use characteristics.

Dr Murphy, back from a fellowship at Canada's Lethbridge Research Centre in Alberta, said the results of his hydrological research there were a surprise to both himself and his Canadian colleagues.

"The Lethbridge Centre had a series of replicated plots including natural grassland, abandoned cultivation and sown introduced pastures. The site was established in 1993 to compare production and nutrient status over a long term.

"The general school of thought was that the sown introduced pastures would exhibit the best water cycling characteristics and production potential. To our surprise, these proved to be less effective at capturing rainfall and tended to shed more water as surface run-off, perhaps due to a combination of reduced litter, less groundcover and reduced carbon cycling leading to lower stability of soil aggregates. The introduced grasses, Russian wild rye (*Elymus junceus*) and crested wheatgrass (*Agropyron cristata*) were generally more tussocky and had less herbage mass, which allowed bare soil to be exposed and some surface crusting to develop.

"Under the sown grasses soil carbon and nitrogen levels were also declining compared with the natural grassland, which was maintaining these levels by generating high amounts of litter and root turnover.

"The native grassland was better able to harness rainfall than the sown species, but the regenerated grassland on abandoned cultivation was the best in the trial.

"It appears the disturbance caused by a one-off cultivation of the soil 13 years ago which had provided enough stimuli to the C and N cycles to allow the regenerated pasture to produce more dry matter and lay down high amounts of pasture litter."

Dr Murphy said his research in Canada has implications for native grass pasture management in Australia.

"In order to improve water-use characteristics for our native grasslands, it may be necessary to provide some form of disturbance, such as over-sowing subclover and applying superphosphate or perhaps direct drilling an oat crop into the grassland to 'kick start' the system," he said.

Interestingly, Dr Murphy said the native grass species in southern Alberta, which are widely used for cow-calf enterprises, are no more productive than those in Australia.

In something of a paradox, while Canadian agriculture is relatively unconcerned about dryland salinity, Dr Murphy said there were certainly early signs developing.

"Southern Alberta received record rainfall totals for June in both 2005 and 2006 and this flux of water clearly showed that water logging and saline scalds are developing in low lying areas and adjacent to dryland cropping."

Canadian researchers have developed a highly efficient and portable rainfall simulator for studying surface hydrology of pasture and agricultural systems. Dr Murphy aims to bring this technology back to Australia to use in his work on the *Agronomy of subtropical grasses* project at Tamworth, particularly to study the impact on surface run-off characteristics.

"The rainfall simulator can apply low or high 'rainfall' intensities in a very uniform pattern. It's portable, easy to operate and is ideal for assessment of remote sites because you don't have to cart large amounts of water, which is currently the case with many Australian simulators."

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Highlights

- Prairie grassland research in Canada has implications for Australia native grassland management
- Canadian natives are better at water and nutrient cycling than introduced pastures
- Waterlogging and saline scalds are developing.

Correction to 'Perennials put to the test in SA'

Apologies to readers for an error in the graphs of *Seasonal production of perennial herbs chicory and plantain at Keith and Willalooka* published as Figure 3 on page 4 of *Focus on Salt #38*. The correct version is shown below and also in the web version at www.crcsalinity.com.au.

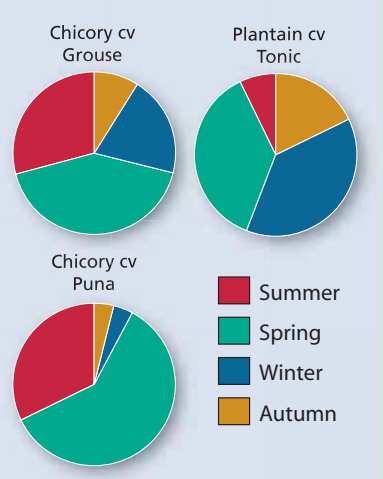

Figure 3. Seasonal production of perennial herbs chicory and plantain at Keith and Willalooka South

To market to market — harvesting $$ from saltland

Many questions related to profitable use of saltland now have answers following recent research, but those answers need better packaging and marketing to industry.

This was the major conclusion from the CRC's recent WA Node meeting.

Twelve researchers and PhD graduates presented the findings of their research and its impact on industry, after which the research was assessed by an industry panel representing farmers, consultants, agribusiness, grower and NRM groups. This seven-member 'assessment' group offered advice on how to better deliver and market the CRC's work.

WA Node Manager and Principal Research Scientist, Dr Richard George, summarised the observations and insights from the day:

- 'Good' saltland, of which WA has about 500,000 hectares, should be seen as a specific soil type that can offer farmers production and conservation benefits

Photo: G Bailey

Grazing management and fertiliser trials — profits to be made with salt-tolerant pastures

- Risk of failure is a central concern to growers, for whom anything less than a 90 per cent success rate is unacceptable. As a result, the Future Farm Industries CRC must deliver a site classification system that ensures the right plant is targeted to the right site
- Producers need more objective tools to plan and lay out a saltland system, and also basic agronomic information such as fertiliser requirements and herbicide response
- Understorey is critical to the saltbush option and there is a critical need to continue breeding more salt-tolerant legumes, grasses and shrubs
- Salt-tolerant cereals being developed by the CRC could be dual purpose crops and pastures
- Engineering and plant-based options should be seen as complementary
- Motivation to act is part stewardship, part risk management, and part confidence-driven; highlighting the need for different systems to meet different needs
- An important outcome of the *SGSL* program is the evolution of a regionally based network of growers and advisers with significant experience and skills.

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Salt can be a health hazard

Salt may be a human health hazard and not just when it's in the only water available to drink. That is becoming more apparent now, through some postgraduate research in Western Australia.

Three CRC Salinity PhD students, Andrew Jardine, Scott Carver and Peter Speldewinde, are looking at different aspects of health and salinity in the face of predictions that saline areas in the semi-arid agricultural region of south-west WA (currently estimated at about 1 Mha) could triple or even quadruple before equilibrium is reached. These health effects include dust-related respiratory health; altered ecology of the mosquito-borne disease Ross River virus; and mental health consequences of salinity-induced environmental degradation.

Peter Speldewinde is undertaking a health survey of farmers to determine if there are actual negative health outcomes from living in saline areas.

"The combined influences of agricultural practices, a seasonally arid environment and dryland salinity yield favourable conditions for aerosolising soil particles and microbes, which can cause serious health problems," Peter says. "In Australia and overseas increases in asthma symptoms are associated with dust storms, including the effects of fungi and other pathogens attached to the dust. Given the decrease in vegetation cover, there is potential for more wind-borne dust and associated health effects. During summer residual pesticides and chemicals may be transported with wind-borne dust also."

Scott Carver and Andrew Jardine are studying whether the prevalence of mosquito-borne diseases such as Ross River virus could rise because of larger areas of salt marshes. Salt marshes are the primary breeding habitat for the mosquito *Aedes camptorhynchus*, the major vector of Ross River virus in southern Australia. Their research shows this species is well established in saline areas in inland WA.

"We have also found the absolute abundance of *Ae. camptorhynchus* is very high in salt-affected areas, possibly due to rising water tables and increasing surface water retention, enhancing the potential habitat for the mosquito," say Scott and Andrew. "Furthermore, salinity has negative influences on aquatic biodiversity, which might restrict the mosquito's natural competitors and predators."

To date Andrew and Scott have not found any evidence of an increase in human Ross River virus cases.

Ecosystems affected by dryland salinity display many characteristic symptoms of Ecosystem Distress Syndrome which has been shown to have a negative impact on human health. If the extent and severity of dryland salinity in Australia increases in coming decades this could have further human health implications.

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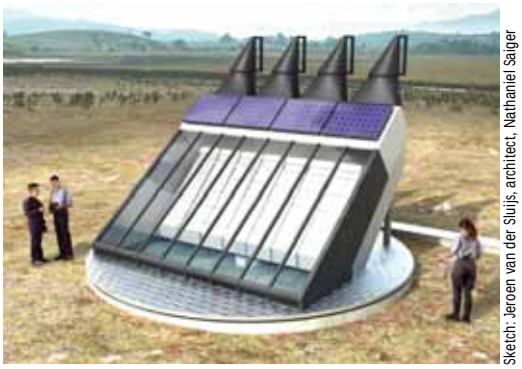
Desal using 'free' energy

If ever there was a right moment for a 'water machine' it is surely now, but much of the talk of desalination keeps coming up against the high cost, including energy, needed to drive the process.

Frequenters of the CRC Salinity's online forum (http://forum.crcsalinity.com/forum/) and Saltlist, might be aware of posts from a Dutch architect, Jeroen van der Sluijs, who has designed a unique solar still.

Actually, Jeroen has been discussing this for a couple of years, keen to establish a collaborative business arrangement with interested parties in Australia.

Focus on Salt does not advocate nor advertise commercial products or businesses, but as this solar still is based on readily understood scientific principles it seems reasonable to give readers an insight to this piece of technology.



Sketch: Jeroen van der Sluijs, architect, Nathaniel Saiger

HAFO Solar Still with suntracker

"The HAFO Solar Still produces distilled water and of course salt. As well as its obvious application in desalinating seawater or groundwater, it can also purify effluent water that is free of volatile liquids," says Jeroen.

"The system is driven by solar energy but performance can be enhanced by pre-heating water by means of a wind rotor.

"Energy efficiency modeling predicts an average daily capacity for the 20 m² unit as 500–800 litres, which can be boosted to 900–1400 L with a wind rotor. Mid-summer average daily yields are about 20 per cent higher than annual daily averages, while peak yields on a hot, cloudless summer day with some wind (to drive the rotor) can reach 2 kL.

"These modelled results have an uncertainty +/- 20%, and a prototype will be trialled for 12 months in South Australia's Riverland to get accurate production data.

"The distilled water from the unit can be shandied to varying degrees with the source water to allow it to be used for irrigation. If the water is to be used for drinking, a downstream mineral filter will be installed together with the unit.

"The solar stills produce raw salt that is quite dry (if run in batch mode) and can be stored temporarily near the stills. When running the stills in continuous mode, the distillation rate will increase slightly, however the output will be concentrated brine that will then pass to an evaporation pond or solar pond nearby on site.

"In inland areas, batch mode will usually be the preferable option, producing almost dry salt. Near the coast, continuous mode will be attractive as the brine could then be discharged into sea some distance from the shoreline, where the sea depth and current are sufficient to quickly disperse the brine without creating an environmental risk. In this mode, the stills only need to be cleaned about once a month."

Jeroen van der Sluijs hopes to find an Australian collaborator, active in the water treatment or supply industry, willing to assist with building a prototype so performance testing can begin in 2007.

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Just the facts

As many of the CRC Salinity's research projects reach maturity they are delivering a wealth of information, captured in summary form in a series of fact sheets.

The CRC is not printing hard copies of these but making them available online at www.crcsalinity.com.au > Publications > Key publications. You will notice that there are two versions – screen quality (for quick download) and print quality (suitable for printing for field days and similar events).

Some fact sheets describe information that is of limited relevance outside the State in which the research was undertaken. These show the identity of that State and the government agency that led the research. Others carry information widely applicable across state borders — in such cases we have prepared versions for each State so users can readily see the relevance to them.

The CRC has also recently prepared a summary brochure for its *Salinity Information Framework 3 (SIF3)* project that is attracting a lot of interest from catchment management authorities. This will be followed early in 2007 by a series of related fact sheets.

About Focus on Salt

Focus on Salt is published by the CRC for Plant-based Management of Dryland Salinity (CRC Salinity) in collaboration with the CRC for Landscape Environments and Mineral Exploration (CRC LEME).

CRC Salinity core partners are Charles Sturt University (CSU); Commonwealth Scientific and Industrial Research Organisation (CSIRO); Department of Agriculture and Food WA (DAFWA); Department of Environment and Conservation WA (DECWA); Departments of Primary Industries (DPI) and Sustainability & Environment (DSE), Victoria; NSW Department of Primary Industries (NSW DPI); Departments of Primary Industry and Resources (PIRSA) and Water, Land and Biodiversity Conservation (DWLBC), SA; The University of Western Australia (UWA); The University of Adelaide (UA).

CRC Salinity supporting partners are Australian Conservation Foundation (ACF); Australian Wool Innovation Limited (AWI); Office of Science and Innovation, WA (OSI); Grains Research & Development Corporation (GRDC); Land & Water Australia (LWA); Meat & Livestock Australia (MLA); Murray-Darling Basin Commission (MDBC); National Farmers' Federation (NFF); Rural Industries Research and Development Corporation (RIRDC); Landmark AWB.

For information about CRC Salinity visit www.crcsalinity.com.au.

CRC LEME is an unincorporated joint venture that brings together groups from The Australian National University; CSIRO Exploration and Mining and CSIRO Land and Water; Curtin University of Technology; Geoscience Australia; Minerals Council of Australia; NSW Department of Primary Industries; Primary Industries and Resources SA; The University of Adelaide.

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