Saltland prospects

2007

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Prospects for profit and pride from saltland

FUTURE FARM
INDUSTRIES CRC
PROFITABLE PERENNIALS™ FOR AUSTRALIAN LANDSCAPES

foreword

Saltland Prospects is an in-depth publication designed especially for farm consultants, advisers, agronomists and leading farmers keen to investigate what profitable options are available for salt-affected farmland. It brings together six years of research, and farmer case studies that featured prominently in the highly regarded *SALT Magazine*.

As the Chief Executive Officer of the Future Farm Industries Cooperative Research Centre (FFI CRC) and its predecessor, the CRC for Plant-based Management of Dryland Salinity (CRC Salinity), I commend this booklet to you. The knowledge it contains is current and relevant, and builds on CRC Salinity's successful demonstration that production from salt-affected land can be profitable and well integrated with enterprises on the whole farm.

In a 'first' for Australia, *Saltland Prospects* features a nation-wide saltland classification system. This land capability system will align farming systems best suited to individual farms, with estimated productivities for 15 growing regions across Australia.

Saltland Prospects is one in a series of Prospects Statements that summarise key Profitable Perennials™ technologies and farming systems to come from CRC Salinity. These now offer new opportunities to limit the onset of dryland salinity while improving productivity of grazing and cropping systems, and natural resource outcomes across Australia.

Why release this publication when the focus of environmental concerns in recent years has shifted away from the salinity threat to the new uncertainties of climate change and Australia's declining water resources?

It is good news that dryland salinity is unlikely to rise to the levels predicted during 2001, in part due to the recent dry climate sequence. However, salinity has already damaged an estimated two million hectares of farmland and is still a major threat to water resources, biodiversity, regional infrastructure and more farmland.

It still makes good economic, environmental and social sense to target our salinity management efforts on protecting the most valuable assets at risk. The combination of dryland salinity and climate change means that farmers will seek to be more efficient and selective with their land use and that natural resource management will have to be more finely tuned.

Saltland Prospects is the start of a series of products from FFI CRC, designed to assist farmers, their advisers and natural resource managers in making decisions based on new knowledge.

Another salinity management product soon to be launched by FFI CRC will be *Saltland Genie*, a web-based tool to assist farmers in making informed decisions about the best farming system to manage dryland salinity on individual farms. It will be supported by other land-capability assessment tools for saline land, *SaltCap* and *SaltDecide*.

Furthermore, FFI CRC proposes to create the *Salinity Knowledge Exchange*, an online learning site and library that draws together the latest research and development and farmers' experiences, supported by an extensive knowledge base with training courses and mentoring.

I trust you find *Saltland Prospects* ground-breaking and useful.

Kevin Goss

Chief Executive Officer
Future Farm Industries CRC

contents

Acknowledgements

This document is the result of the unwavering dedication of many people committed to improving the prospects of Australian producers managing saltland. It is testimony to the leadership of the Sustainable Grazing on Saline Lands *(*SGSL*) producer-researcher partnership and the initiative of the CRC for Plant-based Management of Dryland Salinity (CRC Salinity).*

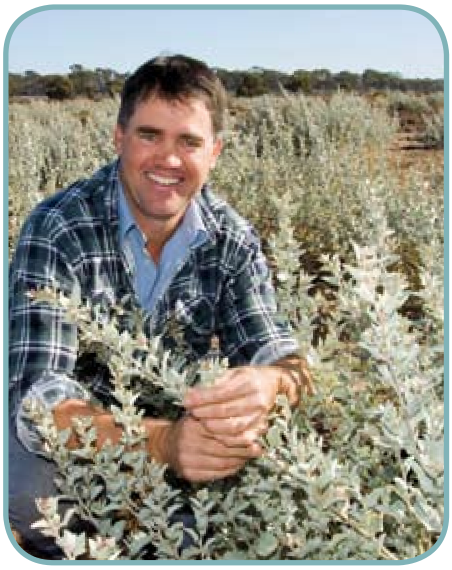

PHOTO: DAFWA's SGSL team and Photographic Branch

Thanks go to:

As a product that integrates the diverse knowledge-base of a broad multidisciplinary team, there are many authors of this document. While most are listed in the bibliography, the tireless contribution to the editing made by David Masters, Nick Edwards, Felicity Byrne, Ed Barrett-Lennard, Warren Mason, Richard George, Jeff Patterson and Stephen Millar cannot go without the highest praise. The production of this Prospects Statement *would not have been possible without the development of the Saltland Capability matrix for which the contribution of the* SGSL *team, and in particular Ed Barrett-Lennard, must be acknowledged.*

Under the coordination of Adrian Webb, ground-breaking contributions were made to bring the Saltland Capability matrix to life by Luke Beange, Andrew Wooldridge, Peter Regan and Deb Slinger (New South Wales); Colin Bastick (Tasmania); Malcolm McCaskill and Trevor Pollard (Victoria); Jock McFarlane, Glen Gale and Nick Edwards (South Australia); and Ed Barrett-Lennard and Phil Nichols (Western Australia). Peter Chudleigh, Felicity Byrne and Andrew Bathgate provided the exacting analysis required for the economic component of the document.

Thanks must also be given to Geographic Information System scientists who have put together the state salinity regions described in the Saltland Capability matrix; Ian McGowen (NSW Department of Primary Industries), David Maschmedt (The Department of Water, Land and Biodiversity Conservation, SA) and Jean-Philippe Aurambout (Department of Primary Industries, Victoria). The case studies have all been adapted from articles in SALT Magazine*. Thanks are given to Georgina Wilson, Michael and Cathy Blake, Bruce Munday and Luke Beange for the original articles.*

Jeff Patterson and Stephen Millar, two of Australia's most insightful and delightful producers, played a valuable role on the project steering committee and strived to keep the document relevant to producers.

An enormous debt of gratitude is owed to David Masters who not only oversaw the project steering committee, but contributed many long days and nights to fine-tuning and correcting the document.

About the authors

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Richard Price is Managing Director of Kiri-ganai Research Pty Ltd. He is experienced in developing and servicing national, inter-disciplinary and multi-organisational environmental and agricultural programs. During 1992 he established and managed Australia's National Dryland Salinity Program*, bringing it to a successful conclusion in 2004. As a senior manager with the Land & Water Resources R&D Corporation he established and managed the* National Climate Variability in Agriculture Program, National Soil Acidification Program, Research Integration and Adoption Program *and the* Social and Institutional Research Program*. Richard was a Board member of the CRC Salinity and helped establish the* SGSL *initiative from which much of the content of this* Prospects Statement *is drawn.*

PHOTO: DAFWA Inset: Sarita Bennett

The prospects for investment in saltland management

Improving saltland can enhance the robustness and flexibility of an enterprise, by providing additional grazing options. It also diversifies risk management options on mixed farms by offering a greater capacity to alter the cropping/grazing mix according to market signals and climate forecasts.

A range of plants exist that can provide significant levels of biomass and support animal production on saltland. From these options, producers are realising a range of benefits. Looking into the future, the emergence of profitable salt-tolerant grains is a possibility, adding further to the resilience of production systems faced with saltland and rising water tables.

Economic benefits

Returns from saltland pastures vary from farm to farm, but usually comprise a mixture of:

- direct value of the additional feed produced
- additional feed available out-of-season, which can provide even greater value
- resting land unaffected by salinity after the break, allowing more autumn/winter production from non-saline pastures
- an increase in efficiency of wool production resulting from salt in the sheep's diet
- intake of beneficial compounds, such as vitamin E, that are prevalent in some saltland pastures during summer
- having a safe and productive area to run sheep while cropping takes place
- a drought reserve in the tough years.

It is the combination of pasture and livestock management that is critical to profitable returns from saltland. Managing higher stocking rates, whether within rotational or set stocking systems, demands greater pasture management as well as animal management skills, but the returns can be significant. Economic modelling outlined in this *Prospects Statement* shows saltland pastures can generate $21–$25 per hectare per year additional profit for a typical 3750 ha property in the eastern Western Australian wheatbelt to $40–$80/ha/yr additional profit for a typical 2000 ha farm in the Southern Agricultural region (with the $80/ha being achieved for the first 50 ha). For a farm in south-west Victoria saltland pastures can generate an Internal Rate of Return (IRR) of 21% for a 10-year pasture life and a payback period after five years. In New South Wales saltland pasture has been reported to provide an average annual value of $85/ha on a farm in the central slopes. All these figures are examples only, as the variation in saline land results in variation in returns.

Environmental benefits

Well managed saltland pastures can reduce wind and water erosion by maximising groundcover on otherwise fragile land. Many producers with saltland invest in saltland pastures for this reason alone. Research suggests increased groundcover on saltland makes a significant difference to managing salinity *in situ* as well as downstream by reducing water, salt and sediment run-off. For example, there appears to be higher water use under saltbush than under unimproved pastures, helping producers control soil moisture and salinity levels.

Biodiversity benefits also exist. Management of saltland for grazing encourages plant species heterogeneity, while higher microbial biomass and respiration have been associated with saltland pastures than with unimproved saltland. These benefits do not require a production trade-off; for example, there is a positive correlation between microbial weight and respiration and livestock production.

Managing saltland improves the resilience and function of landscapes. The dynamics between soils, water, biota and nutrients can be improved by managing saltland with salt-tolerant pastures. For example, in WA revegetation with saltbush and annual legumes has improved infiltration, soil stability and nutrient cycling.

PHOTO: DAFWA's SGSL team and Photographic Branch

Social benefits

Social factors can act as the most powerful driver of managing saltland. There is tremendous personal satisfaction, confidence and pride gained from successfully managing saltland. These social benefits include:

- improved visual amenity of rehabilitated land
- an enhanced sense of meeting social responsibilities and contributing to catchment health
- achievement of a range of personal and family aspirations about the farm and how it is used.

Social benefits often outweigh economic considerations in making decisions about saltland management.

The aim of this document

Saltland on properties across Australia opens new opportunities for profitable agriculture. Many producers are currently managing saltland for a wide range of benefits. Knowledge offered by their experience is supported by a range of research to portray a heartening picture. This *Prospects Statement* captures the existing knowledge base about saltland and uses it to outline the prospects for managing saltland across Australia. Leading producers, their advisers, industry networks, natural resource management groups and research investors alike can use this knowledge to inform investment and management decisions in respect to saltland on farms, across catchments or within program investment portfolios.

introduction

PHOTO: Megan Hele

Managing saltland in an Australian agricultural context

The nature of saltland in Australia

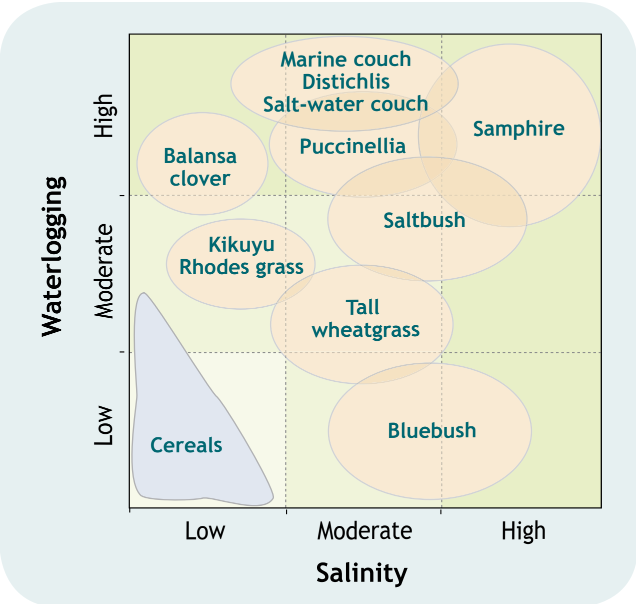
Much of Australia is naturally saline, with extensive areas of primary salinity present before European settlement. About 29 million hectares (Mha) of the country is said to have natural expressions of salinity, including 14 Mha of salt lakes, marshes and flats and about 15 Mha of saline subsoils found across arid and semi-arid landscapes.

The extent of predicted secondary salinity in Australia is presently under question. The National Land & Water Resources Audit's estimate of 17 Mha of regions at risk or with a high salinity hazard by 2050 (defined as land where water tables were less than 2 m or within 2–5 m and rising) has excited debate and demonstrated the vagaries associated with modelling based on patchy data and in a country where climate variability can rapidly alter future scenarios.

However, for many producers salinity is not hypothetical. For them it is real, and it affects their productivity, infrastructure, visual amenity, confidence and aspirations. Saltland is estimated to affect up to 2.1 Mha of arable land, with about half of this in WA alone. The critical factor is not the number of hectares affected, but its cost and the number of producers and others bearing this cost. Land, Water & Wool surveys suggest more than 8000 wool producers alone report some level of salinity as an issue on their properties, while the Australian Bureau of Statistics estimates that about 20,000 of all agricultural producers face salinity as a constraint to production.

Across Australia, the appearance of saltland is highly uneven due to the interactions of variable salt levels with variable soil types and the extent of waterlogging. On many farms salinity is patchy and dispersed, making it difficult to fence and manage as a discrete unit. Here, saltland hardly warrants addressing by individual producers as an economic issue, particularly in the eastern states. For example, in Victoria 69% of woolgrowers with saltland have less than 20 ha affected, while in NSW the figure is 67%. Even in SA, where salinity levels are assumed to be higher, 58% of woolgrowers with saltland have less than 20 ha of salt-affected area across their farms. For producers with low levels of saltland the more important driver of change is the desire to achieve environmental and social objectives. In some parts of WA and parts of SA, the situation is different, with economics a greater motivator for addressing larger tracts of saltland.

FIGURE 1: Saltland capability to support different plant systems



While an east/west delineation is frequently talked about, the reality is there are many farms in the east that display symptoms of the large tracts of saltland not uncommon in the west. Likewise, many farms in the west exhibit the patchiness commonly associated with salinity in the east.

For this reason, it is important to delineate strategies for managing saltland according to its different characteristics. A useful way to do this is to consider the 'saltland capability' of an area. Salinity and waterlogging are two major factors contributing to saltland capability (see Figure 1), however in practice other factors such as soil characteristics, rainfall and site topography are important. The region-by-region options for managing saltland that appear in this *Prospects Statement* use a practical framework based around saltland capability.

A social and technical history of managing saltland

Most saltland in lands developed for grazing or cropping is the unintended consequence of past decisions, policies and actions. For much of the twentieth century sporadic efforts were made to deal with it, but the past five to ten years have seen a crescendo of interest and investment in saltland pastures and more generally in the productive use of saline resources.

The emergence of secondary salinity has been observed in Australia since the early twentieth century. By 1924 the causes and processes of salinisation were understood, documented and notified to government, initially by a WA railway engineer, W.E. Wood. But such understanding came well before researchers developed a capacity to predict how widespread salinity would become. The prevailing policy regimes that encouraged agricultural growth and development across Australia meant saltland became an increasingly common part of agricultural landscapes.

With vast regions of land turned to agricultural production, there was little prospect of any wholesale reversal of land-use practice after salinity appeared. Instead, producers responded by working around salt-affected patches, either fencing off saltland or simply cultivating to its edges. Agricultural agencies recommended fencing off to control further degradation by grazing and supported limited research into salt-tolerant species selection and propagation.

Plant-based solutions pursued by producers were largely directed towards learning to live with salinity. Some of the efforts had a goal of rehabilitation in the hope of restoring land to a state where it could again be cropped. In many cases graziers either ignored saltland as a minor inconvenience or introduced salt-tolerant species as much for aesthetic reasons as for production benefit. By the late 1980s about 9000 ha of saltbush were being planted per year.

Surface and sub-surface water manipulation has also been adopted. As early as the 1950s, WA producers attempted to use forms of drainage, including water interceptor systems along farm contours to reduce water moving to discharge zones on farms. By 1980, membership of Wittington Interceptor Salt Affected Land Treatment Society

introduction

(WISALTS) — named after its founder Harry Wittington — rose to more than 1000 producers across Australia, with at least a third of all WA wheatbelt farmers participating. The expectation that drainage systems provide the best chance to mitigate salinity still drives substantial engineering works across the wheatbelt.

More recently, many producers have combined their livestock management know-how with knowledge about saltland pastures to develop their own productive solutions to saltland. When this trend first gathered momentum the prevailing policy paradigm did not recognise their efforts. Most natural resource management programs were more concerned with preventing saltland and public investment in research focused largely on recharge management and in working at the catchment scale. Producer groups such as the *Saltland Pastures Association* came to the fore as a means of enabling salt-affected producers to provide peer support and create strength in numbers.

A maturing of the concept of sustainable agriculture within natural resource management programs has enabled some refocusing of attention on saltland, and this has lead to industry and government collaborations, such as the *Sustainable Grazing on Saline Lands* project.[1] *SGSL* has identified productive options for about 50% of salt-affected land across Australia, and these are outlined in this *Prospects Statement*.

"I can illustrate grazing potential (of saltland) with the example of a 150 ha paddock we bought about 10 years ago. There was about 8 ha of arable land, and the rest salt, and in pretty bad shape. Initially we grazed about 50 dry sheep on the area for about three months each year. Since then it has been revegetated with bluebush and saltbush and we run 300 lambing ewes in there over a four-month period each year. Not a bad effort for land that many would consider useless. Of course, not all paddocks are as good as this one (but) we feel that saltland is very beneficial to our farming enterprise. The whole grazing operation is more productive and we can spell some of the arable land at the break of the season, putting sheep on the saltland to allow pastures on the arable land to get away. We are certainly not afraid of buying saltland, because well managed it can be a valuable asset."

Tony York, mixed farmer, Tammin, WA

How *Saltland Prospects* helps

This publication outlines the prospects for saltland agronomy in southern Australia.

It covers:

- the diverse nature, causes and impacts of salinity across Australia; evolution of responses to salinity challenge (Managing saltland in an Australian agricultural context; pages 7-9)
- production benefits, including state-by-state overviews, from saltland management; opportunities and constraints for profitable and environmentally sustainable saltland enterprises and social rewards and challenges (Prospects for managing saltland; pages 10-21)
- salinity management options at catchment and property scales; saltland management in grazing and mixed-farm enterprises; dealing with waterlogging and knowledge gaps (Placing the prospects in a management context; pages 22-27)
- region-by-region recommendations for plant-based systems for managing saltland (Regional prospects for managing saltland; pages 28-53):
  - **Western Australia** — eastern and northern wheatbelt; central wheatbelt; woolbelt and West Midlands; southern coast (pages 30-34)
  - **South Australia** — northern Eyre Peninsula, northern Yorke Peninsula and mid-north; southern Eyre Peninsula and Coorong; southern Yorke Peninsula, Kangaroo Island and upper south-east; Adelaide Hills (pages 35-41)
  - **New South Wales** — northern slopes; central slopes and plains; southern slopes (pages 42-47)
  - **Victoria** — northern districts; south-west districts; Gippsland (pages 48-52)
  - **Tasmania** — National Action Plan region (page 53)
- references (pages 54-56).

[1]*SGSL* is supported by Land, Water & Wool and the Future Farm Industries CRC. Land Water & Wool is an initiative of Australian Wool Innovation Ltd and Land & Water Australia, and also receives substantial support from State government agencies in WA, SA, NSW and Victoria and nationally from CSIRO.

Prospects for managing saltland

Production and profitability

Saltland pasture systems can be both productive and profitable. The extent to which such prospects can be achieved by individual investors will vary according to regional, local and property characteristics; the level of salinity; the plant systems selected; and the attention paid to management.

Importantly, for saltland of the lowest capability, profitable options are not available and identification of these land classes is a key part of any investment strategy. Some saltland needs to be fenced off and isolated from production.

The primary economic benefits of saltland are derived from livestock production. Improving saltland and managing it as part of a whole-farm system can enhance the robustness and flexibility of an enterprise, providing additional grazing options and offering significant financial returns through higher stocking rates.

Saltland pastures can help diversify the feed source on a property both spatially (across the farm) and temporally (across the seasons). In particular, saltland pastures can provide quality feed during summer and help fill the autumn feed-gap. For example, saltbush can provide up to 450 grazing days per hectare during the summer/autumn period. Economists value the autumn feed at up to 10 times the value of feed on ground during spring. Sites planted to saltbush have provided sheep with an average of 35% more Metabolisable Energy (ME) than plots without saltbush.

Returns from saltland pastures can be realised across a range of landscapes, rainfall zones and salinity levels. Table 1 provides a summary of sheep production that can be expected across a range of saltland pasture systems.

Benefits from saltland pastures vary from farm to farm, but usually comprise a mixture of the following:

Direct value of the additional feed produced: Saltland pastures can extend the area of land available to graze on a property. This can assist in managing seasonal variation in feed supply in some situations or may be a core activity where a significant proportion of the farm is salt-affected.

Out-of-season feed value: Salty sites tend to stay wet for longer periods, so they can provide green feed not readily available from non-saline paddocks. In some cases, where waterlogging is the primary problem, careful selection and management of plants can provide higher levels of feed production than on adjacent non-saline sites. This is particularly valuable during the summer/autumn feed-gap when costly supplementation would normally be required.

Whole-farm productivity: Resting land unaffected by salinity after the break allows more autumn/winter production and higher stocking rates on non-saline pastures. Longer spells can also provide soil health benefits and reduce both run-off and deep drainage during the wetter periods in winter-dominant rainfall areas.

TABLE 1: Sheep production from a range of pasture systems in southern Australian saline sites

Predominant pasture species	Time of year	Sheep age (years)	Grazing period (days)	Stocking rate (sheep/ha)	Grazing days	Live-weight change (g/d)	Site location
Sea barleygrass	autumn	1	19	4	76	-51	Unspecified
	summer	0.5	56	9	504	-71	Katanning, WA
	summer	2	56	9	504	-140	Katanning, WA
	winter/ spring	1.5	227	2	454	66	Keith, SA
Mixed volunteer species	autumn	1	30	15	450	-61	Unspecified
Tall wheatgrass (TWG)	summer	2	56	10	560	-140	Katanning, WA
	summer	0.5	56	10	560	-71	Katanning, WA
TWG/sea barleygrass	summer	1	52	10	520	-21	Glenthompson, Vic
TWG/tall fescue/ phalaris/perennial ryegrass/annual legumes	autumn	1	48	31	1488	77	Yass, NSW
Sweet clover/TWG	summer	1	28	75	2100	80	Glenthompson, Vic
Puccinellia	summer	0.5	56	8	488	43	Katanning, WA
	summer	2	56	8	488	18	Katanning, WA
	winter/ spring	1.5	227	5	1135	83	Keith, SA
Puccinellia/ balansa clover	summer/ autumn	1	63	10.5	662	-44	Mt Charles, SA
Balansa clover/ Italian ryegrass	summer	0.5	56	10	560	48	Katanning, WA
	summer	2	56	10	560	18	Katanning, WA
Old man saltbush	autumn	1	50	13	650	18	Yealering, WA
River saltbush	autumn	1	50	13	650	12	Yealering, WA
Saltbush and mixed understorey	autumn	1	30	15	450	-61 to 4.5	Unspecified
Saltbush/balansa clover	all seasons	1	250	7	1757	120	Unspecified
Saltbush/balansa clover	summer/ autumn	1	19	8	152	80	Tammin, WA
Saltbush/small leaf bluebush/ volunteer grasses	autumn	3	42	15	630	-2 to -105	Pithara, WA

FIGURE 2: Wool production at different salt levels

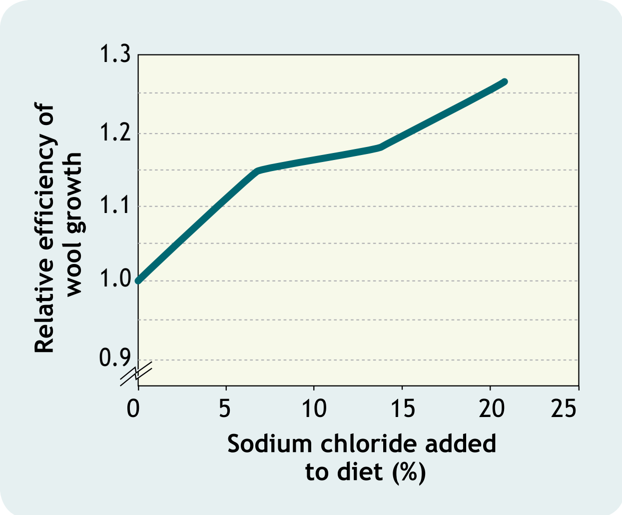


PHOTO: Hayley Norman and Megan Hele

Efficiency of wool production: The conversion efficiency of feed into wool (wool grown per kilogram of organic matter intake) can be increased by up to 25%, across a range of diet types, when sodium chloride is included in the diet at up to 20% (see Figure 2). Similar improvements in feed conversion efficiency have been observed in sheep grazing saltbush. This improvement probably relates to changes in protein digestion associated with increased water intake.

Addition of certain nutrients: Saline pastures can contain compounds that influence livestock production and health. Some of these will provide benefits. For example, it has recently been shown that saltbush is a valuable source of vitamin E during summer. Vitamin E is low in dry feed and a deficiency will result in muscle damage and possibly even death. In WA alone, it has been estimated more than one million sheep each year are supplemented to overcome this deficiency. Vitamin E can also improve the shelf-life and colour of meat.

Improved meat production: Moderate amounts of sodium in either drinking water or feed can lead to a reduction in meat fat and an increase in protein in the carcass. There is anecdotal evidence that sheep grazing saline pastures produce meat with improved eating quality. While this improvement has not been confirmed in scientific studies, the comparisons have indicated that lambs finished on a combination of saline pastures and grain are of a similar standard to commercial lamb.

Amenity value: While there is evidence that investing in saline land specifically for production purposes is profitable, revegetation of saline land also improves amenity, often for aesthetic reasons. It is likely this will increase the overall value of the property, often above that expected from productivity increases alone.

Anecdotal evidence from producers has identified other benefits:

Growth rates: Palatable green feed from saltland improves weaner growth.

Parasite control: Grazing saltbush reduces worm burdens and drenching requirements.

Risk management: Feed value from saltland pastures offers some buffering to climate risks and poor seasons.

prospects

Balansa clover is a productive legume on low saline, waterlogged soils

The productive use of saltland is viewed by many producers to be more profitable than reclamation or doing nothing. This finding is supported by economic studies for a range of saltland pasture systems across Australia:

Western Australia

Whole-farm modelling of a representative farm in the southern agricultural region showed that inclusion of saltland pastures can generate about $4000 extra profit for a 2000 ha farm. This was equivalent to $80/ha of saltland pasture, based on revegetation of 50 ha of moderately saline land. As the area revegetated increased to include mildly and severely affected saltland (115 ha in total) the average profit of saltland pasture decreased to $40/ha.

As this was a whole-farm economic analysis, economic benefits beyond the direct benefits of saltland pastures (i.e. as a feed source) were accounted for. These include a) the provision of feed at a time when on-farm feed is limited and costly supplements are used, and b) the benefit of delaying grazing on annual pastures at the break of season, which increases pasture growth and allows a higher stocking rate. Of the financial benefits of the saltland pasture system about two-thirds came from reduced supplementary feed costs. The remaining one-third of the benefit came from the increased stocking rate.

Key profit drivers were the summer/autumn nutritional quality of the saltland pasture, summer/autumn production levels and reduced establishment costs. The actual profitability of saltland pastures will vary largely from farm to farm due to differences in a whole range of variables including: severity of saltland, area of saltland, climate, livestock system and establishment costs. In some cases it will not be profitable to establish saltland pastures at all. However, the economic benefits and profit drivers as outlined here will tend to remain the same for mixed crop and livestock systems across the WA wheatbelt.

South Australia

Saltland pastures in SA have been used by many producers, including by some in a sequential perennial system (a form of using pioneer species in preparation for the subsequent introduction of new, longer-term options). Here the saltland pastures act to draw down the water table sufficiently to grow lucerne. A case study farm showed such a system turned a 725 ha property from being unviable (losses of $62/ha/yr under its existing system) to a highly profitable one ($77/ha/yr). Another farm switched from profit at full equity of $8/ha/yr to $147/ha/yr, profiting principally from the more intensive cropping options provided on the remainder of the farm, but also from the intensive grazing on the original saltland component.

Whole-farm analyses have shown grazing from improved puccinellia pastures more profitable than grazing unimproved pastures in SA research sites. If reasonable production levels can be achieved the profit increase was shown to be about $50/ha, with an establishment cost of about $250/ha and average maintenance costs of about $20/ha/yr.

Improving saltland pasture with tall wheatgrass (left) and a mix of annual species can bring financial benefits to grazing systems

Victoria

Whole-farm analysis indicates that establishing tall wheatgrass-based pasture is profitable on mildly and moderately saline land, in south-west Victoria. The analysis was conducted for a 700 ha farm with 50 ha of salt-affected land. The results showed that profit could be increased by more than $200/ha on mildly saline land, by increasing the stocking rate across the whole farm by one sheep per hectare and reducing the rate of supplementary feeding through autumn. However, the results show that high returns depend on high feed utilisation and quality and this requires sound grazing management.

This result is consistent with a budget analysis completed using data from another farm monitored under the *SGSL* program. Whilst profits were in the order of $50/ha less on this farm, the increase in stocking rate was also slightly lower. However, the long growing season typical for south-west Victoria, high stocking rates and short autumn feed gap lead to large benefits from improving saltland pasture.

New South Wales

Net returns from establishing saltland pastures (saltbush) were about $85/ha in a case study completed for a farm in the Cowra Shire. This result is consistent with a whole-farm analysis conducted for the Central West Slopes. This analysis indicated that the net benefit of improving saltland pasture with tall wheatgrass and a mix of annual species is $50–$80/ha depending on the flock structure of the farm, prime lambs providing greater profit than a wool-only flock. This result assumes lucerne is grown on some of the non-saline areas. Where lucerne cannot be grown successfully (for example, due to sub-soil constraints) the value of saltland pasture is much greater. Benefits of up to $130/ha were estimated for farms without lucerne, using production data from a research site. Saltland pasture is more valuable in the absence of lucerne, as lucerne can substitute for saltland pasture to some extent, providing better quality pasture.

The potential of saltland pasture in NSW can be limited to some extent because salinity often affects small areas of land and fencing these small areas incurs higher costs per unit area. Whilst profit is not particularly sensitive to establishment costs, higher up-front costs can be a disincentive for some producers to improve pastures on saltland.

PHOTOS: Matt Crosbie Inset: Nick Edwards

Constraints to production and profitability

Limited plant options: The scope to improve profitability on saltland, and the capacity to change farming systems to incorporate perennials, varies markedly across Australia. Producers in the low to medium rainfall zones, including the sheep/cereal mixed farming belt of southern Australia, have far less options for managing salinity while maximising profit than those in the higher rainfall zones, particularly in respect to increasing the proportion of the landscape sown to perennial plants. This is for a range of reasons:

- annual plants have historically been seen as the main option in farming systems in southern Australia, and plant improvement programs have reinforced this. Change is as much a cultural issue as an economic one
- few perennial options are available that can withstand seven months of drought
- some exotic perennial species have been excluded on grounds of weed potential
- many shrub species and perennial legumes have been rejected on the basis of low biomass productivity and/or presence of anti-nutritional factors
- the effectiveness of many existing plantings has been minimal.

Risk aversion: Consultations, surveys and case studies clearly show that pasture establishment costs and the risk of non-establishment are perceived as significant and remain the highest barriers to adoption. The costs include preparation for sowing, seed and fertiliser, sowing and fertiliser application. Fencing costs to bring saltland into rotational grazing systems also are significant, but less-expensive electric fencing is an option for small areas. On the other hand, changes required to introduce grazing into the whole-farm system, such as fencing and watering points, can present obstacles later in respect to cropping phases. Moreover, the patchiness of salt distribution on many farms makes fencing aligned to land characteristics highly problematic.

The cost of establishing productive saltland pastures varies greatly, and has been found to range from $73/ha to more than $700/ha across a range of sites (average $277/ha). The number of years to break even at these sites from livestock production varies from 3–20 years.

Limited livestock management skills: Grazing management systems and skills in relation to saltland vary. Some croppers facing the prospect of managing saltland may not have previously managed either pastures or livestock. In some areas, finding labour to make up for a lack of experience, skills or confidence is either difficult, costly, or both.

Low nutritional value of salt-tolerant plants: Under more saline conditions, plant systems start to incorporate a halophytic component within the mix — grazing on salt-tolerant shrubs often proves substandard, with livestock only maintaining or even losing weight. This is because they are low in nutritive value, and their edible biomass is also relatively low. Subsequently, the economics for improving saltland with halophytic shrubs alone is marginal. For saltbushes, the fodder has:

- low ME concentration (high animal production requires high energy concentration) when expressed as a proportion of total Dry Matter (DM) production but a reasonable concentration when expressed as a proportion of the organic material in the plant
- high crude protein (high animal production requires moderate to high levels)
- high salt concentrations (high animal production requires relatively low salt concentrations).

Poor animal production can be attributed to overestimation of organic matter availability (counting salt content, which has no energy value), the energy cost of excreting salt from the body, the decrease in organic matter digestibility with high salt intakes, appetite suppression, and the possible content of a range of secondary compounds that affect plant palatability. The same secondary compounds that can help plants survive inhospitable conditions, such as saline environments, can be detrimental to grazing livestock. These include betaine, tannins, coumarin, oxalates and nitrates.

Alternative options: Economic studies of alternative or complementary solutions, such as engineering works, remain scarce. Construction and maintenance costs can be high and profitability depends on production increases and the area over which they occur. The impact of engineering works needs to be considered in a catchment context as increased flows of saline water may have adverse consequences downstream of the drain.

Sustainability and biodiversity

The environmental prospects of managing saltland are positive. The ecological benefits from appropriate management of saltland can be seen through improved biological function, structure and species composition. Appropriate management will result in improved water management, landscapes and biodiversity. Providing groundcover where land is particularly degraded is an essential and common response, mitigating against further degradation, and addressing the aesthetics of the landscapes concerned.

Saltland pastures show high potential for large-scale improvement of saltland conditions and for subsequent delay or abatement of further downstream degradation problems. Most alternative production-based land uses are too niche-focused to have widespread impact. In these situations even low levels of adoption can sometimes saturate available markets for the products they produce.

"We wanted an option to keep this land within our animal production system while preventing it from becoming more saline. This project (SGSL) *gives us that opportunity. We are also hopeful that as a result we can reclaim some land that is already saline. It is all about halting the spread of salinity while maintaining the health of the areas. We are still feeling our way of course, but are hopeful this is the way of the future for us."*

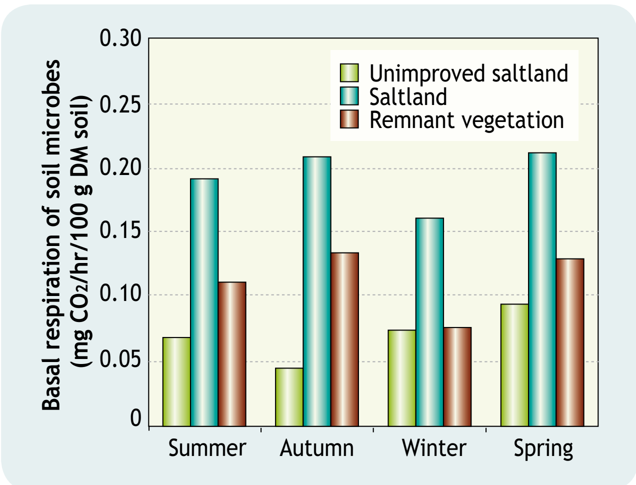
Deane Aynsley, mixed farmer, Quairading, WA.

Landscape function

Saline land is fragile and poor management will erode ecological systems. Salinity and waterlogging affects the diversity, survival and functionality of a range of ecosystem components. Perennial-based pastures can use stored soil moisture during dry periods and reduce recharge during the next rainfall event, decreasing the rate of water table rise. Halophytic plants can dry out the soil above the water table or even lower the water table in some circumstances. This allows salt to be leached from the upper soil profile creating niches for the establishment of less salt-tolerant annual plant species.

On a smaller scale, revegetation of saltland has led to increased microbial respiration and biomass. Microbial activity is important for nutrient cycling and soil stability. As an example, Figures 3 and 4 compare basal respiration of soil microbes and total soil microbial biomass of soils collected in unimproved saltland, adjacent saltbush stands and adjacent degraded remnant vegetation at a site in Tammin in the medium rainfall woolbelt of WA. The figures indicate that basal microbial respiration was highest in the revegetated saltland plots. Additionally, in three out of four seasons, total microbial biomass was lower in unimproved saltland than in revegetated saltland.

FIGURE 3: Basal respriation of soil microbes (mg CO_2/hr/100g DM) within soil cores collected across transects of unimproved saltland, saltbush plots and adjacent degraded remnant vegetation at Tammin, WA, 2004



At sites across Australia, Landscape Functional Analysis (LFA) has been used to assess the functional state of the respective saline landscapes. Figure 5 shows the combined soil surface assessment indices of stability, infiltration and nutrient cycling for saline soil in the upper south-east of SA. Individually these indices indicate the ability of the soil to withstand erosive forces, the water-holding capacity of the soil and the efficiency of organic matter recycling back into the soil, respectively. In this instance, the remnant vegetation provides a benchmark for landscape function but saltland that has been 'improved' by the establishment of salt-tolerant pastures is still in a better functional state than a salt scald. LFA assessments at Tammin similarly suggest that revegetated saltbush plots have a higher value for all three LFA indices (although the remnant vegetation was degraded).

FIGURE 5: Soil surface assessment indices for saline land revegetated with saltland pastures (pastures 1,2 and 3), left as remnant vegetation or degraded to a salt scald in the upper south-east of SA

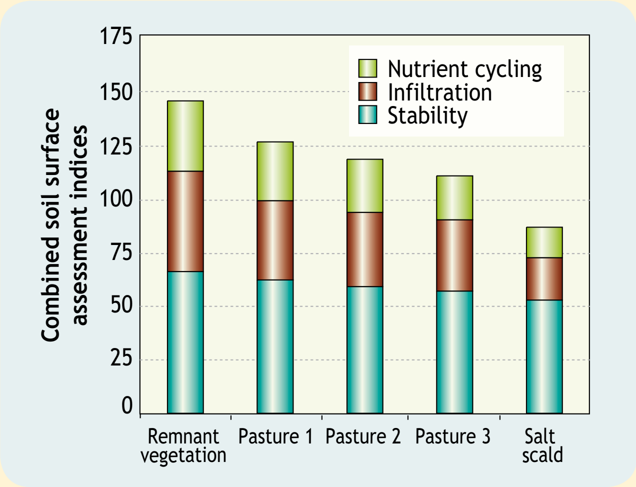
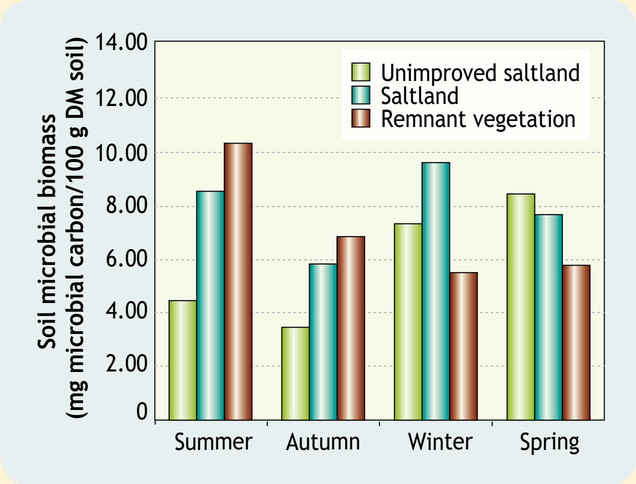


FIGURE 4: Soil microbial biomass (mg microbial carbon/100g DM) within soil cores collected across transects of unimproved saltland, saltbush plots and adjacent degraded remnant vegetation at Tammin, WA, 2004



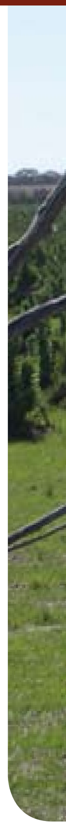


PHOTO: Sarita Bennett

Structure and composition

While plant composition of saltland is important for the productivity of a system, increases in plant diversity should also buffer the system from changes spatially and over time. Table 2 contains data from a site in Yealering, in the medium rainfall woolbelt of WA. Rows of saltbush seedlings and a range of annual legumes were planted at this site during 2004. As a result, the revegetated plots contain seven more plant species than the unimproved plots. A greater proportion of the plant species in the revegetated plots are native and have a perennial lifecycle (leading to greater summer water use).

The increase in annual biomass from 1.4 t/ha in the unimproved plots to 7.7 t/ha in the revegetated plots is likely to lead to higher transpiration rates during spring. Biodiversity benefits do not require a production trade-off. This site is a clear example of a win-win situation for both biodiversity and animal production. More than 60% of the 7.7 t/ha of DM produced in the revegetated plots was from a range of annual legumes with a higher feeding value than the barleygrass in the unimproved plots and with the ability to fix atmospheric nitrogen for the soil.

TABLE 2. Plant diversity and plant biomass production from unimproved saltland and an adjacent revegetated plot in Yealering, WA during spring 2005. The same biomass data has been presented on the basis of life form (legume, halophyte, grass or forb), origin (native or exotic) and by lifecycle (perennial or annual).

Species	Unimproved saltland			Saltbush and sown understorey		
	Number of species	Biomass (kg DM/ha)	% of biomass	Number of species	Biomass (kg DM/ha)	% of biomass
Legumes	2	72	5.1	8	4735	61.3
Halophytes*	0	0	0	2	704	9
Grasses	3	1181	84.2	4	1953	25.3
Forbs	6	150	10.7	4	337	4.4
TOTAL	**11**	**1403**		**18**	**7729**	
Native	1	42	3	3	719	9.3
Exotic	10	1361	97	15	7010	90.7
TOTAL	**11**	**1403**		**18**	**7729**	
Perennial	0	0	0	2	704	9
Annual	11	1403	100	16	7025	91
TOTAL	**11**	**1403**		**18**	**7729**	

*Halophytic biomass was taken as leaves and small stems (edible portion) of saltbush, wood was excluded from calculations.

Careful grazing management of saltbush provides out-of-season green feed, as well as lowering water tables

Constraints to environmental management

Persistence and yield are significant challenges for saltland pasture systems. Biomass production can vary due to a range of soil/water/plant constraints and the variability of these constraints even within a single paddock.

There is a potential for invasiveness of some introduced species, although in some instances the perception might be greater than the reality. In the case of tall wheatgrass, there is the potential to spread along creeks or watercourses, into neighbouring farmland, onto roadsides and into plantations. However, in 60 trial sites in south-west Victoria, it has been reported that little spread actually occurred. Where it did occur, it was usually where there was less competition (i.e. bare areas along roadsides). Grazing management which limits seed set reduces invasion risk significantly.

Many grain producers are concerned that introducing animals into their system could compound soil compaction and other potential resource management problems. While sound livestock management practices can lead to both profitable and positive environmental outcomes, poor practices can contribute to run-off and erosion, and water and nutrient leakage.

The cultivation required in the initial establishment of saltland pastures can increase short-term water, salt and sediment run-off from the site. While this is likely to be reversed after the establishment period, limited quantitative information is available.

Salt water disposal remains a practical issue where surface water management practices, such as shallow drainage, are required to support effective pasture and agronomic practices.

Finally, in areas with highly saline and acidic groundwater, the bio-availability and potential toxicity of metals in saline water remains unknown.

Self-reliance and pride

Most landholders have less than 20 ha of salt-affected land on their property, so social drivers play a major role in the adoption of saltland management strategies.

Social benefits of agricultural systems are often portrayed as a by-product of the economic and environmental legs of the triple bottom line. In a survey of wheatbelt farmers managing saltland, more than 84% stated they were motivated to manage their saltland so as to prevent further loss of their productive land. However, more than 80% stated that turning unproductive saltland into productive land gave them a sense of satisfaction that reinforced their decision to invest. For many successful saltland managers, an enormous sense of pride is achieved, especially where visual amenity is greatly improved.

PHOTO: DAFWA's SGSL team and Photographic Branch

Social considerations are a key driver, particularly where saltland is small or patchy. In such cases, economics seldom plays a major part in the decision to invest in saltland management as saltland pastures are unlikely to be the 'next best' investment on the farm. While it can be profitable, other farm investments, including buying more land, often provide a better return on investment. However, although producers want to know what investing in saltland will 'cost' them, they have a myriad of ways they expect to 'benefit'.

A range of social-based aspirations motivate producers to manage saltland and adopt saltland pastures. These can be relational or cultural. Relational aspirations are those where action is driven by the desire to gain recognition among family members, peers, neighbours or other significant people in the lives of the producer. Cultural aspirations are those where producers respond to peer expectations.

However, adoption of new practices also establishes a personal sense of control over an individual's own destiny. The most significant personal drivers of action can be emotional and aesthetic aspirations. Emotional aspirations can drive producers to act out of the desire to resist or fight the threat of salinity or to achieve the sense of satisfaction of having overcome adversity. Aesthetic aspirations are those that drive changes that fit with desirable images of the landscape they conjure and aspire to live within.

Some social dimensions of saltland management are based on risk management strategies and attitude to risk. An important driver of change is the need to respond to changes that are taking place around the business of farming. Market movements, resource condition, regulations, climate, emerging challenges and opportunities constantly change. The ability to appropriately plan for these and respond and adapt can make or break farm profitability, resource condition, quality of life and well-being. For some, saltbush is used not to manage saltland *per se* but to manage climate-associated risks. The introduction of saltland pastures into a farming system provides a sense of resilience.

The institutional environment surrounding saltland pastures today is more supportive than it once was. Organisations that support both agriculture and natural resource management are recognising that the two issues are not trade-offs and as a result the support mechanisms for sustainable agriculture are increasing. From a community perspective, the notion of productively using saltland carries less environmental stigma and public criticism than it once did.

Social constraints to achieving benefits

Moving into, or in some cases returning to, mixed farming systems can present a number of challenges. Labour scarcity throughout rural Australia is increasing as the number of farm families declines and services available from rural towns continue to diminish. Mixed farming systems will require additional service support, which is not always available at competitive cost. Moreover, mixed enterprise systems generally demand more time, often during periods when producers would traditionally take holidays if they remained as pure grain producers. Lack of animal and grazing management skills is also a significant issue.

"We are also very satisfied that we have been able to overcome a challenging problem and happy that the two properties look a lot better for it."

Andrew Southwell, woolgrower, Rye Park, NSW

In regions such as those across Victoria and parts of NSW, land values, changing social structures and changing land ownership patterns suggest non-agricultural pursuits are often the most rational use of land. This means the responsibility for managing saltland may increasingly lie with inexperienced owners, or with people with no interest in agriculture at all. Subsequently, a greater emphasis could be placed on reclamation as a strategy for managing saltland.

Social factors can constrain willingness to adopt new practices, including the landholders life stage (younger producers with high debt or older producers about to 'retire' could be less motivated to risk taking on new practices); and a producer's 'riskframe' within which decisions are made (i.e. risks could be perceived differently during droughts and boom times). Anecdotal evidence suggests many with saltland face a range of anxieties, including feelings of denial, failure or anger, and this can undermine their confidence to respond, either rationally, effectively or at all.

PHOTO: John Powell

Producers such as Andrew Southwell (above) gain a sense of personal pride at being able to overcome the challenges presented by saltland management

Placing the prospects in a management context

Where to start

From an economic perspective, saltland that is moderately saline offers the best opportunity. Managing saltland with low salt levels has a higher opportunity cost (i.e. it can still be better to crop despite lower yields). Managing saltland with high salt levels increases the risk of failure.

Catchment management context

Saltland can be found across a range of groundwater flow systems but is more frequently associated with local systems. Some of the most significant areas of salt-affected land are found in the wheatbelt of Western Australia which is dominated by local groundwater flow systems. These systems respond relatively rapidly (compared with intermediate and regional flow systems) to reduced recharge which can result from a well established saltland pasture. While this effect will be of benefit to the individual farmer at this site, the benefit is unlikely to extend further across the catchment. Other benefits such as reduced saline wash-off from saltland and possibly reduced saline baseflow to watercourses might be experienced across the catchment, although there will be a time lag before these are recorded.

Intermediate and regional groundwater flow systems are so large and sluggish that recharge reduction due to saltland pastures is likely to have less impact on water tables even directly under the pasture. This will be particularly the case when the saltland occurs in relatively small patches. In such cases the only real benefits will be to the immediate landholder.

However, taking advantage of the patchiness of saltland can contribute to establishing wildlife corridors and act as the impetus for creating a stewardship ethic that extends across the farm.

What are groundwater flow systems?

The groundwater flow system was developed to differentiate regions across Australia according to their dominant salinity process as measured by hydrological characteristics influencing the time lag between the occurrence of recharge and discharge. Local systems are those where the time lag is relatively short (20–50 years), intermediate systems can have a 50-100 year time lag, while regional systems could have lags of more than 100 years.

PHOTOS: CSIRO Land and Water and B. Woolford

Property planning context

The key to meeting aspirations for managing saltland, whether for rehabilitation or profit, is that saltland is accorded a place in the overall plan for the farm business. A successful plan should include:

- a clear understanding of the aspirations for the farm and those family members and staff associated with it
- identification of the risks and opportunities, including those relating to markets, natural resources, and human and capital resources
- an understanding of the processes of salinity in the landscape as a precursor to planning specific treatments and solutions
- an understanding of the management options that align with land suitability, opportunities and aspirations
- an understanding of the role of other strategies, such as lucerne, in improved water use and management to reduce recharge
- an understanding of the costs and benefits of the options, including appreciation of the investment flows over time
- identification of alternative strategies that come into play given certain scenarios, including drought and price downturns
- an appraisal by an objective, knowledgeable and trusted confidante
- a commitment to its implementation and time dedicated to assessing progress.

Successful mixed farms are those that deal with decisions about crops, pastures and livestock as if they are all part of one system. Any decision made on part of the system will inevitably have an impact on other parts even though it may not be immediately obvious or occur in the short-term. Integrating the system needs to occur at the planning stage.

"We now have about 120 ha across both properties under our saltland system. We have recorded what all our paddocks carry during a 12-month period and surprisingly the saltland carries 11 DSE/ha/yr on average, while the improved pastures on non-saline land carry only 8 DSE/ha/yr! We have learned it is essential to get onto the saltland before you lose too much topsoil from erosion. Salt-tolerant pastures actually generate more profit on our properties than improved pastures on the non-saline land because the sowing costs per hectare are about the same, but the carrying capacity of the saltland is higher. The saltland is essentially an underground irrigation system during dry summers and autumns – it has become an integral part of our rotational grazing system."

Andrew Southwell, woolgrower, Rye Park, NSW.

Production systems

Most profitable options for managing saltland are based around grazing saltland pastures for either wool or meat production. Much of what is known is summarised in the book, *Saltland Pastures* (Barrett-Lennard *et al*. 2003). More specific work dealing with animal management is to be found from CSIRO Livestock Industries and the FFI CRC. Despite work already done, much of what is known about animal management on saltland is still anecdotal and has emerged from producer experience.

Grazing dominated systems

Salt-tolerant plants provide an additional feed supply across the farm and skilled livestock managers can improve their value by supplementing them with low quality feed (dry pasture or crop stubble). Moreover, saltland can be a key part of a whole-farm grazing rotation system. In this respect, producer case studies highlight the following:

- rotational grazing to improve persistence and productivity
- matching whole farm feed supply with livestock requirements across seasons
- allowing rest periods to repair scalded land and restore biodiversity.

PHOTO: Jo Curkpatrick

Salt-tolerant plants such as puccinellia (above) provide an additional feed supply across the farm

Grain producers are increasingly expanding into mixed farming systems

Mixed farming rotations

There is pressure on many grain growers to enter into, return to or increase livestock production on their farms irrespective of the presence of salinity. This is for several reasons:

- reacting to a long-term fall in grain prices, coupled with an increase in the profitability of some livestock production systems
- a profitable pasture phase, enabling producers to manage water and nutrient leakage through the inclusion of perennials
- managing climate change and price risks through enterprise diversification
- managing herbicide resistance by breaking grain-on-grain production systems
- managing a range of weeds.

The presence of saltland can play a role in mixed farming through:

- provision of autumn feed when other grazing paddocks under a mixed farming rotation may be stressed
- complementary use of stubbles with saltland pastures
- introducing livestock onto traditional cropping properties to manage a range of sustainability issues including salinity, soil and nutrient loss, and herbicide resistance
- increasing rotation options, including extending the rest periods for particular crop paddocks.

PHOTO: Kondinin Group

Managing water

Excessive surface water is often associated with saltland. Drainage might be required to improve the establishment and persistence of saltland pastures and maintain land condition to enable grazing with minimum adverse impact (such as soil compaction).

Three forms of drainage are potentially suitable to manage the surface water associated with saltland.

Shallow drains

Shallow drains of various forms reduce the effect of waterlogging and inundation by collecting and diverting surface water run-off away from areas where water can pond and infiltrate, resulting in rising water tables (during winter) and concentration of salts (during subsequent spring and summer evaporation). A key requirement for managing saline land is to keep water tables as low as possible to prevent the strong flow of salt from depth. Diversion banks located upslope of saline land can divert surface water away from saltland sites, assisting rehabilitation and productivity.

Shallow drains are effective where:

- topography is relatively flat and soils are impermeable (e.g. clays)
- surface water can be diverted without large costs
- natural drainage lines are ill-defined or discontinuous.

PHOTO: Greg Hamilton

Raised beds allow drainage to occur in close-spaced gutters alongside the seed-bed

Raised beds

Raised beds are a specific form of drainage that require land to be engineered in such a way as to allow the seed-bed to be elevated and drainage to occur from close-spaced gutters. Beds are typically 2-3 m wide and up to 1000 m long in ideal locations.

PHOTO: DAFWA

Shallow drains are effective on flat landscapes

PHOTO: DAFWA's SGSL team and Photographic Branch

Deep drains

Deep drains can intercept the water table and control groundwater levels to contain salinity or bring salinised land back into production. However, the production potential will depend on what happens to soil chemical and structural characteristics during and after water tables have fallen. Deep drains also remove excessive run-off and reduce waterlogging but are relatively expensive to construct. They are usually dug to a depth of 1.5 to 3 m.

The effectiveness of deep drains depends on establishing a safe disposal point and locating them in permeable and structurally stable soils.

Drainage water may be highly saline or acidic and so the impact that water may have on the receiving water bodies needs to be established. Alternatives to deep drainage can include pumps and siphons, and require installation with shallow drains and/or raised beds.

Conclusions about prospects, risks and opportunities

The prospects for managing saltland across Australia are bright. Producers are motivated to make their saltland profitable, and the increased returns for livestock industries bodes well for introducing saltland pastures onto saltland, and subsequently introducing previously unproductive land into the whole-farm system. Producers are successfully doing this and leading the way with innovative farm practices.

However, the diverse nature of saltland means it cannot all be managed in any one way and the reasons for managing it, and how it is managed, will reflect a wide spectrum of economic, environmental and social aspirations. And so while for each of these factors the prospects for managing saltland are positive, the constraints and risks need to be acknowledged and paid due respect. Here there is an important role for combining the experience and innovation of producers across the country with the technical assistance of the country's researchers and specialist advisers.

PHOTO: Sarita Bennett

Deep drains can effectively remove excessive run-off and reduce waterlogging but are relatively expensive to construct

What are the key research and development gaps?

Not everything is known about maximising the economic, environmental and social benefits of managing saltland, and research issues remain. Following are some of the areas where further knowledge needs to be pursued.

1. **Profitable animal systems for saltland**

   Research in this area can address grazing management for increased productivity, improved Merino sheep performance from saltland pastures systems, saltland pasture systems for healthy sheep and parasite control, cattle maintenance and backgrounding on saline land, low-input meat sheep production systems for saltland and understanding the issues around livestock reproduction on saline land.

2. **Characterisation and identification of revegetation options**

   Research in this area can assist producers to characterise their land and make decisions about the most appropriate options for managing it, long-term profitability and environmental benefits. This calls for assessment of cause and effect relationships between landscape function and landuse (involving better documentation of water use and water management on saltland and land at risk, and water movement under halophytic shrubs) and integration of saltland into farming systems through bio-economic modelling.

3. **Better plants for saltland**

   Research in this area can address screening of saltbush and other salt-tolerant plants for nutritive value, palatability, growth rates and recovery from grazing. There is a need for hand-held screening techniques for rapid prediction of nutritive value of plants in the field, re-evaluation of other chenopod species not well understood, factors generally influencing palatability, and analyses through bio-economic modelling to investigate whole-farm benefits and impacts of changes in nutritive value of biomass production from salt-tolerant plants.

4. **Aligning surface and sub-surface water management to support saltland management options**

   Research in this area can address the role of surface and sub-surface drainage in enhancing the success of saltland management strategies, while ensuring minimal environmental harm.

Regional prospects for managing saltland

The prospects for managing saltland across Australia will vary from region to region. However, as suggested in an earlier section of this report, there will be significant differences within regions because of the variable nature of saltland.

This section outlines the recommended plant-based systems for managing saltland across 15 regions in Australia, using broad categories of 'saltland capability'. These regions include:

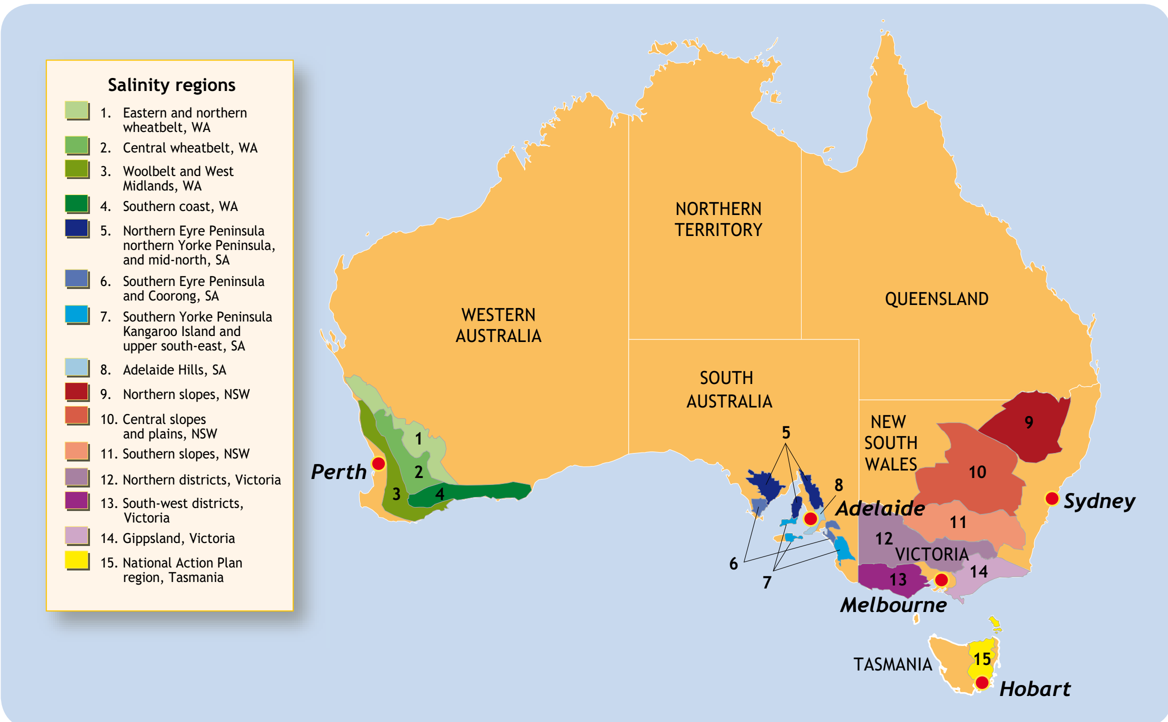
- **Western Australia** — (1) eastern and northern wheatbelt, (2) central wheatbelt, (3) woolbelt and West Midlands, (4) southern coast.
- **South Australia** — (5) northern Eyre Peninsula, northern Yorke Peninsula and mid-north, (6) southern Eyre Peninsula and Coroong, (7) Southern Yorke Peninsula, Kangaroo Island and upper south-east, (8) Adelaide Hills.
- **New South Wales** — (9) northern slopes, (10) central slopes and plains, (11) southern slopes.
- **Victoria** — (12) northern districts, (13) south-west districts, (14) Gippsland.
- **Tasmania** — (15) National Action Plan region.

The outline for each region considers the broad capability of the saltland (from low to high), key site characteristics (indicators) to assist producers to identify their category of saltland, the plant system likely to be most suited to the category and region, and a ranking on the plant system's productive potential. A brief comment is also provided on the available knowledge base within each of these regions.

A case study within each state details the successful incorporation of saltland pastures into a local farm. However, the examples given can be extended across southern Australia depending on the scale of salinity and waterlogging on each farm. Table 3 shows which saltland pasture systems can be used in each of the 15 regions.

Upon choosing the best saltland pasture system for each farm, it is recommended farmers and their advisers access state and regional expertise, and local experience for reliable establishment and management.

FIGURE 6: Australian salinity regions



regions at a glance

TABLE 3. Regions of southern Australia, along with salinity and waterlogging saltland capability classes, into which saltland pasture systems could be extended.

Main vegetation region	(WA) Saltbush with understorey	(SA) Puccinellia	(NSW) Mixed pasture species	(VICTORIA) Tall wheatgrass
Western Australia				
Eastern and northern wheatbelt	low to moderate salinity, low to moderate waterlogging	–	–	–
Central wheatbelt	low to moderate salinity, low to moderate waterlogging	–	low to moderate salinity, low to moderate waterlogging	–
Woolbelt and West Midlands	–	moderate to high salinity, high waterlogging	low to moderate salinity, low to moderate waterlogging	low to moderate salinity, no waterlogging
Southern coast	–	with companion legumes; variable salinity, high waterlogging	low to moderate salinity, low to moderate waterlogging	–
South Australia				
Northern Eyre Peninsula, northern Yorke Peninsula and mid-north	low to moderate salinity	–	–	–
Southern Eyre Peninsula and Coorong	–	moderate salinity, some waterlogging	–	–
Southern Yorke Peninsula, Kangaroo Island and upper south-east	–	moderate to high summer salinity, winter inundation		moderate summer salinity, some waterlogging (areas unsuitable for lucerne)
Adelaide Hills	–	with tall wheatgrass; low to moderate salinity; some water logging	–	with puccinellia; low to moderate salinity, some waterlogging (areas unsuitable for lucerne)
New South Wales				
Northern slopes	–	–	seasonally saline	low to high salinity, low to moderate waterlogging
Central slopes and plains	–	–	seasonally saline, no waterlogging; low salinity, seasonal waterlogging; waterlogged and saline	–
Southern slopes	–	moderate salinity, seasonal waterlogging	–	low to moderate salinity, low to moderate waterlogging
Victoria				
Northern districts	low to moderate salinity, no waterlogging	moderate to high salinity, low to high waterlogging	low to moderate salinity with some waterlogging	low to moderate salinity, low to moderate waterlogging
South-west districts	–	low to moderate salinity, moderate to high waterlogging	low salinity, low to moderate waterlogging	low to moderate salinity, low to moderate waterlogging
Gippsland	–	low to moderate salinity, moderate to high waterlogging	–	low to moderate salinity, low to moderate waterlogging
Tasmania				
NAP region	–	moderate to high salinity, moderate to high waterlogging	low to moderate salinity	low to moderate salinity, low to moderate waterlogging

Eastern and northern wheatbelt, Western Australia

Background

This region encompasses the low rainfall areas of the wheatbelt (<350 mm mean annual rainfall), embracing the northern and eastern agricultural regions. It covers about 11.4 Mha. While grain is the major commodity, there is limited wool and, more recently, prime lamb production present in mixed farming systems. Beef production is starting to emerge on some properties, particularly in the north.

About 380,000 ha of land is severely salt-affected (Land Monitor) and it is forecast that between 15–30% of the area could develop a shallow water table and a high salinity hazard (although current rainfall patterns have stalled groundwater rise in some northern areas).

FIGURE 7: Eastern and northern wheatbelt region, WA

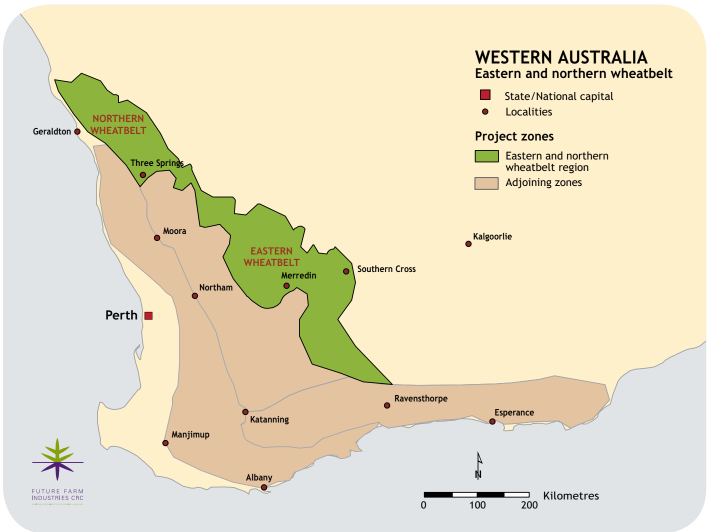


TABLE 4. The prospects for managing saltland in the eastern and northern wheatbelt, Western Australia

SALTLAND CAPABILITY	INDICATORS	RECOMMENDED PLANT SYSTEM	PRODUCTIVE POTENTIAL (Grazable DM yield; value for grazing)
LOW (low capability)	Inundated, high salinity Scalded, clayey, samphire, curly ryegrass	Samphire	Low (less than 0.5 t/ha; not suited to grazing)
	Prone to waterlogging, moderate to high salinity Patchy scalding, sea barleygrass, samphire on more affected boundary	Dense saltbush	Low to moderate (0.5 to 1.0 t/ha; will maintain sheep if supplemented with quality hay and understorey)
	Morrel soils, moderately saline, low to moderate waterlogging Sea barleygrass, bluebush	Bluebush	Low to moderate (<1.0 t/ha; will maintain sheep if supplemented with quality hay)
HIGH (high capability)	Duplex soils, low to moderate salinity and waterlogging	Alleyed saltbush with understorey	Moderate (~1.0 t/ha; sheep will gain weight if annual legumes available in understorey)