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Saltland Pastures

for South Australia

A do-it-yourself manual for the selection, establishment, management and evaluation of saltland pasture systems

Government of South Australia
Department of Water, Land and Biodiversity Conservation

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Saltland Pastures for South Australia

Compiled by
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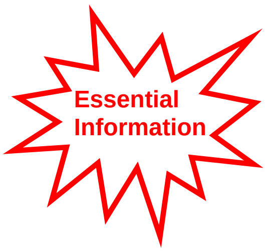

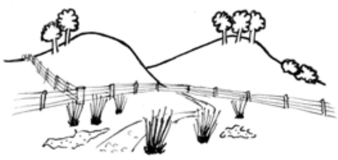

More detailed information


COSTS
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1 INTRODUCTION

Summary points:

- After looking through this manual, landholders should be able to:
  - ✓ Better understand the potential of saltland pastures.
  - ✓ Characterise their saltland.
  - ✓ Recognise suitable pasture plants for different classes of saltland.
  - ✓ Appreciate other site factors that influence production and profitability.
  - ✓ Access tried and tested establishment and management techniques.
  - ✓ Use tools for evaluating economic performance.
  - ✓ Appreciate the payoffs and pitfalls experienced by other farmers working with saltland.
  - ✓ Better understand whether or not saltland pastures are likely to be a success for them.

1.1 A NEW WAY OF LOOKING AT SALTLAND

Salt-affected land has traditionally been viewed as unattractive and low productivity land. But increasingly, farmers faced with dryland salinity are recognising the valuable opportunities this land holds. Following the examples set by leading producers throughout many of the agricultural regions, a range of salt-tolerant pastures is being utilised to improve the land, providing both productivity and environmental benefits. Seeing examples of success in areas relevant to the farmer can provide a powerful motivation for change.

When looking to develop saltland, factors such as the productive capacity of the land (eg. levels of salinity, waterlogging, etc.) and appropriate species for the site and farm enterprise, are prime considerations. It is also important that native vegetation on saltland is protected in accordance with the *Native Vegetation Act 1991* (see Section 6.1.2, page 46). At times saltland can be a difficult environment to become experienced with. Early failures at pasture establishment should not discourage overall plans for development.

Saltland grazing involves both discipline and opportunism. Discipline in grazing management is required to keep appropriate cover on the ground over summer to help control soil salinity levels. On the other hand opportunities arise, for example, with valuable out-of-season feed and in the flexible application of fertiliser to make the most of favourable seasonal conditions.

1.2 ABOUT THIS MANUAL

Background

This manual has been developed through the ‘Sustainable Grazing on Saline Lands’ (SGSL) research and development program. SGSL was a five-year nationwide research and development program designed to provide wool growers and meat producers who are living with salt-affected land the most up-to-date, best bet information to enable sustainable, profitable production from saltland pastures. The SGSL program comprised a combination of activities based upon:

- research conducted at five major national research sites,
- locally relevant research trials initiated and conducted by wool and meat producer groups, and
- knowledge sharing through regional and national networks.

Bringing together existing knowledge and new findings arising through the SGSL program, this manual aims to provide a synthesis of the current state of knowledge in the field of saltland pastures, with a focus on South Australian conditions. While it is a compilation of the best available information we don't profess to have all the answers. Knowledge of saltland pastures is continually developing and producers are encouraged to seek further information, and particularly, local expertise. We are confident however that this manual will inform producers of the range of opportunities for gaining improved production from saltland.

Who is it for?

This manual provides information and resources to producers and extension workers who need to know more about saltland pastures.

It is both for farmers starting 'fresh' and those who want to get more out of their existing saltland systems.

The discussion focuses on areas of saltland influenced by shallow groundwater. However some of the plant species covered may also be suited to other types of salinity (see Glossary for different 'salinity types').

What will the manual tell me?

Woven into the story of this manual are 5 critical questions that a landholder needs to address before making firm decisions on saltland pasture establishment. These are:

- ***Question 1. How do I decide if saltland pastures are for me?***
- ***Question 2. What do I need to know about my site?***
- ***Question 3. How do I select the right plants?***
- ***Question 4. How do I get my saltland pastures established?***
- ***Question 5. How do I get the best out of my saltland pastures?***

Of course these questions are connected and therefore difficult to view individually. Indeed, 'Question 1' requires answers to the remaining questions for a well thought out decision to be made.

Many readers will only have time to delve into the areas of immediate interest to them. However, to gain a good understanding of the information available, a more thorough read is recommended.

1.3 WHERE CAN I FIND THINGS?

The following will be useful in trying to find items of interest in this document:

- ***Contents*** (page i).
- ***Flowchart*** – describing the format of the manual (Figure 1, page 4).
- ***Index*** (page 137).
- ***Links*** & ***tools*** – as described below.
- ***References & further reading*** (page 126).
- ***Glossary*** – for the definitions of a number of terms (page 129).
- ***Contacts and websites*** – details for chasing up more information (page 133).
- ***CD-ROM*** – containing electronic tools (eg. the 'profitability calculator') and other resources, attached at the end of this manual.

Links

Information in this manual has been compiled from a number of sources, including research organisations, state government agencies, extension workers and landholder groups. Links to some of these external sources are included through the text and are shown by the following icon:

- ***Links*** include websites, contact phone numbers, email addresses, etc. – if the reader wishes to follow up on information that is beyond the scope of this manual. External sources of information are also listed in the 'Contacts and websites' section.

Tools

Useful tools which aim to assist landholders in the decision making process are denoted by the following icon:

- ***Tools*** include the 'profitability calculator' (see Section 12), figures and tabulated procedures through the manual. The profitability calculator (which allows producers to estimate the profitability of pasture systems under different scenarios) and a range of other resources are included on a CD-ROM at the back of the manual.

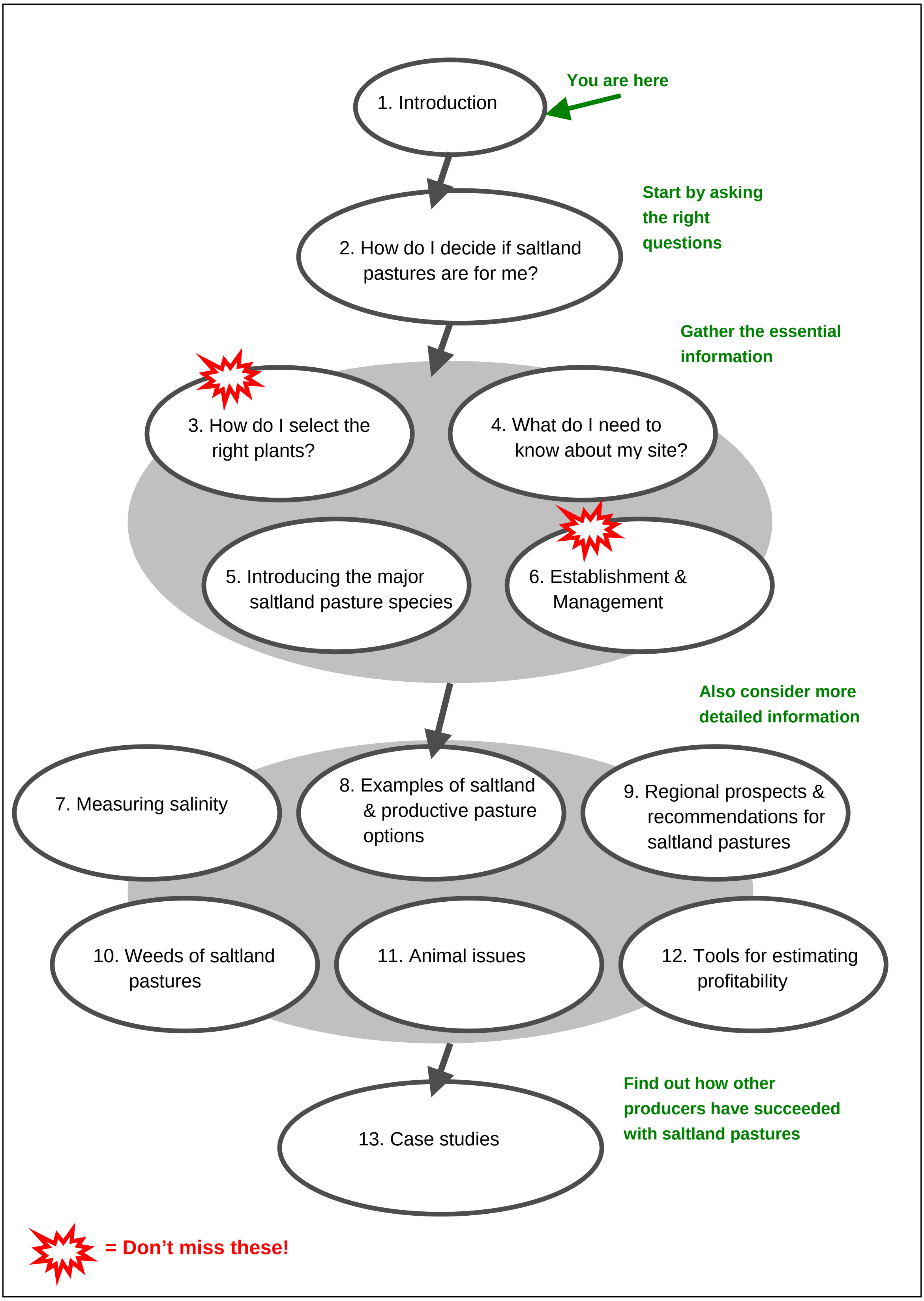


Figure 1. Flowchart: format of the manual.

2 HOW DO I DECIDE IF SALTLAND PASTURES ARE FOR ME?

Summary points:

- There are <u>sound economic reasons</u> for establishing saltland pastures.
- Benefits are best appreciated in the <u>context of whole farm operations</u>.
- Motives for tackling saltland (eg. profit versus pride) often drive landholder's decisions. But no one can ignore the economics.
- A range of factors will determine the likelihood of success with saltland pastures (eg. groundwater behaviour [seasonal dynamics], soils, drainage, suitable pasture species, grazing management, the current farming enterprise and climatic variability).
- Potential profitability needs to be assessed on a case by case basis.
- To fully assess potential profitability requires a good understanding of the most productive saltland pasture systems for a site, and what is required to get them to perform (ie. costs versus benefits).
- Good decisions can be made when armed with good information. But first it is important to ask the right questions!

2.1 SELLING POINTS FOR SALTLAND PASTURES

Selling points for saltland pastures include:

- ***Managing salinity and achieving environmental benefits.***

  Well managed saltland pastures provide cover on saline ground over the heat of summer. This will not get rid of salt, but will keep its impacts to a minimum. Cover on this otherwise fragile (and sometimes bare) ground will provide additional benefits including reduced wind and water erosion, higher water use and increased biodiversity values.

- ***Increased stocking rates on previously low value grazing land.***

  This allows greater numbers of stock to be carried year round, enabling a greater income through accumulated annual gross margins. Typical saltland pastures will provide grazing for around 4 - 5 DSE*/ha. Well managed saltland pastures can provide grazing for 8 DSE/ha or more. This compares favourably with 1 DSE/ha or less from unimproved, salt-affected land. (*See Glossary for definition of DSE.)

- ***Reductions in requirements for supplementary feed.***

  Salty sites tend to stay wet for longer and can offer extra feed that is available out of season. This means cost savings via cutting back on grain or hay purchases, fodder conservation and storage, and supplementary feed production on the farm itself.

  Most economic benefit is gained if saltland pastures are used to fill the autumn feed gap, when the value of feed is at a premium. Out of season feed production has been estimated to be 4-10 times more valuable than extra pasture during the spring flush. This increases the relative value of the saltland pasture and costs of re-development are recovered sooner.

- ***Greater control of paddock use, including non-saline land.***

  Greater feed production on saline land might free up good (non-saline) land, that was previously used in hay production for supplementary feed. This could allow more productive activities such as cropping which would add considerably to farm gross margins.

  After the break of season, grazing saltland can reduce pressure on non-saline pastures, allowing the latter to provide more late autumn-winter production.

  Stock running on the stubbles can be pulled off before damage occurs, because saline pastures will offer an alternative and valuable feed in summer-autumn.

- ***Reduced grass seed problem.***

  Perennial saltland pastures offer reduced grass seed problems. Conditions are usually too saline for silver grass, while sea barley grass seed can be kept to a minimum through adequate weed control and maintaining dense saltland pasture stands. Grazing pastures with reduced grass seed problems leads to improved animal health, higher wool production and higher wool prices.

- ***Increased value of farm land.***

  The economic value of a farm property is determined by relating it to similar country that has recently sold. On grazing properties, comparable values are often determined by calculating land values per DSE. That is, highly productive land, capable of running more stock, has a higher market value than land with poor productivity. Within a district, land generally maintains a similar value per DSE (eg. $150 per DSE). Increasing overall farm production and stocking rates through developing saltland pastures should therefore reflect positively in the value of the land asset.

  In terms of how farmers feel about the land, returning an eyesore back into production is valuable in its own right.

- ***Drought proofing the farm.***

  Saltland pastures are suited to zones of groundwater discharge where moisture often continues to discharge during prolonged dry spells. This moisture has accumulated (often below the rootzone of annual plants) after travelling via groundwater over significant periods of time. Therefore these areas of the farm may not be as susceptible to drought as zones where plants rely purely on rainfall. [The extra moisture available on saltland is what allows farmers to prolong the growing season, thereby reducing reliance on supplementary feed.]

  Plants such as saltbush, are particularly drought tolerant. These plants, often described as a ‘living haystack’, can survive through tough times while providing useful feed.

- ***Increased efficiency of wool production.***

  Moderate salt concentrations in a sheep’s diet have been shown to increase the efficiency of wool production. Increases in the quantity of wool grown per kilogram of organic matter intake (associated with saltbush mixed with supplementary feed) have been recorded in the order of 20-25% (Barrett-Lennard et al., 2003).

- ***Weed control benefits.***

  In a mixed cropping and sheep farm, greater numbers of sheep can be retained year-round. These animals can provide good summer weed control when grazing on the stubbles. And by reducing the numbers of new animals brought onto the farm (as often occurs in line with normal de-stocking and re-stocking practices during and after late summer-autumn), the weed seed load in introduced sheep is reduced. Further weed control benefits are obtained where on-farm hay production is reduced. Oats are traditionally grown for hay but there are less selective herbicides available to control ryegrass in oats, particularly the escapees after the hay is cut. Reducing the requirements for hay production reduces this weed seed bank.

2.2 WHAT DO I WANT FROM MY SALTLAND?

The main reasons for growing saltland pastures are:

- to minimise the impact and spread of salt;
- to increase farm profitability (and capital value); and
- to improve the appearance and environmental health of land which can otherwise be a spreading blight on the property.

Aesthetics

If the reason for tackling saltland is purely to improve the look of the farm then you may not need to establish saltland pastures. Some species (eg. tall wheat grass) should not be planted if there is no intention to graze.

Fencing, controlled grazing and allowing salt-tolerant native species to re-establish will improve aesthetics and provide biodiversity values. Similarly if the saltland area is small and inconveniently shaped it may be best managed for environmental benefits. Some on ground works programs (eg. Coorong LAP) may provide incentives to help with fencing costs to achieve this.

Production

If saltland comprises a significant proportion of the farm there may be real opportunities for gains in production and profit through saltland pastures. The benefits of establishing saltland pastures can flow right across the whole farm operation, as discussed in Section 2.1.

In extreme cases, optimising production from saltland can be a matter of survival. And farmers who are already dealing with saltland on a daily basis have often recognised how to manage this land for profit and sustainability. These farmers are some of the best sources of information on saltland pasture establishment and management.

Leading saltland producers can be found in most agricultural districts and particularly in the Upper South East, Coorong Districts, Yorke Peninsula, Eyre Peninsula and Kangaroo Island.

2.3 EXPLORING THE FACTORS THAT INFLUENCE ADOPTION

The decision whether or not to establish saltland pastures will require the careful thinking through of a number of key issues. In short these can be reduced to the following questions:

- What are the fundamental reasons for my interest in saltland pastures?
- Which saltland pasture systems are best suited to my site?
- What beneficial outcomes are possible if I can get this system performing, within the limitations of my site and farm enterprise?
- What are the costs and other implications of striving for this?
- On balance, would the benefits outweigh the costs?

To explore the key issues in more detail, these questions can be expanded under a range of different topic headings. The questions raised below are not exhaustive but indicate some of the issues that should be considered.

Making an informed decision will require the reader to assess which pasture system(s) best suits their needs, as well as the likely benefits, costs and other implications. Through a step-by-step approach it is hoped that this manual will help streamline the decision making process.

Sustainability

- Is the productive use of saline land an essential part of my strategy for controlling the spread of salinity and keeping the farm going?

Farming system

- How can saltland pastures be integrated with the existing enterprise?
- Is grazing a part of the farming system?
- Are there options to agist stock, cut hay or harvest seed?
- Do I have the right equipment or affordable access to it?
- Are there any animal health issues from grazing saltland pastures?

Aesthetics

- Will the rehabilitation of saline areas boost property values, and thereby justify the expense?
- Does landholder pride and the desire to recover degraded saline areas play a role above and beyond economic factors?

Type of saltland

- Is the saltland too salty to grow profitable yields of saltland pastures?
- Is the saltland not salty enough – and capable of growing profitable yields of conventional crops or pastures?
- Is the saltland area big enough to manage separately, or warrant investment?
- What do I do about patchy salinity?
- Is the saltland going to stay salty for the long term, or could it recover within a few years?
- How do my geology, soils and landscape influence the success of my actions to manage and/ or live with salinity?

Risks

- What are the risks associated with doing nothing with my saltland (eg. spreading salt, deteriorating water quality)?
- What are the risks, or potential losses, of establishing a poorly suited or poorly managed saltland pasture system?
- How does climatic and seasonal variability influence my chances of success?

Profitability

- What profits are likely to come through reduced supplementary feeding and/or increased stocking rates?
- How long will it take for profits to be made?
- How do non-salinity related factors (eg. soil depth, acidity, sodicity, climate) influence potential profitability?
- Will higher productivity from saline grazing land free up other areas of the farm (that have been used for grazing or feed production) for more productive activities?
- What will the additional infrastructure cost (eg. fencing, water points)?
- Will the cost of establishing and maintaining saltland pasture be justified?

Information

- Is there enough information, or the right type of information to make informed choices?
- Are there other farmers or groups who have already looked at many of the issues?
- What do I need to know about my site?
- How do I select the right saltland pastures for my site?
- How do I establish saltland pastures on my farm?
- How do I get the best production results from them (eg. fertiliser, grazing management, weed control)?

2.4 ECONOMICS EXAMPLES

A major factor deciding the uptake of saltland grazing systems will be profitability. An adequate economic analysis requires a reasonable amount of site and pasture specific information.

Economic considerations include:

- How the saltland pastures will fit in with the rest of the farming system,
- Expected establishment and maintenance costs (eg. site preparation, fencing, water points, drainage, mounding, seed, fertiliser, weed control, downtime during establishment, type of grazing management and level of input required),
- Price of supplementary feed during the autumn feed gap, which may be substituted by feed from saltland pastures.
- The numbers of extra stock that can be maintained on the farm due to the extra out-of-season feed available via saltland pastures.
- Cattle, sheep meat and wool prices.
- Expected pasture life.
- Payback times.

Economic issues are discussed in greater detail in Section 12 'Tools for estimating profitability'.

Despite this complexity, some 'rule of thumb' estimates have been developed. These have been calculated using a profitability calculator (developed by PIRSA Senior Economist Graham Trengove) and are based on a range of economic factors.

TOOL

The 'profitability calculator' is further discussed in Section 12, and is available in Excel ® spreadsheet format for landholders to input their own figures, via the CD enclosed at the back of the manual.

The following measures of economic performance are discussed:

- Net present value (10%) [NPV (10%)] – this is the total future profit generated from pasture development over the life of the pasture, in today's dollars (assuming a 10% discounting rate).
- Internal rate of return (IRR) – this is the interest rate you could borrow money at and just break even.
- Minimum pasture life – the life of the pasture required to break even. Beyond this time, profits are made.

In theory, a development will make money if the net present value is positive and the internal rate of return exceeds current interest rates (assumed to be around 10% for this analysis). To proceed with the pasture development, producers should be confident that actual pasture life will approach or exceed the expected pasture life (used in the calculator), but at the very least exceed the minimum or break-even pasture life.

Profitability estimates for two saltland pastures systems established on previously low value grazing land (0.5 DSE/ha) are shown below:

- For a ***perennial grass (puccinellia/ tall wheat grass) system***, costing:
  - $230/ha to establish (including seed, fertiliser, weed control, fencing, water points);
  - $30/ha for annual maintenance (fertiliser, weed control); and
  - $40/DSE capital value of extra livestock (the cost of purchasing DSEs to utilise the extra feed).

With 18 months of grazing foregone during establishment, gross margins of $25/DSE and a pasture life of 15 years, the landholder would need to maintain a stocking rate of 6 DSE/ha/yr for at least 5 years to break even. Over the 15 years of the investment (maintaining a stocking rate of 6 DSE/ha/yr) the net present value (NPV 10%) would be around $294/ha, while the internal rate of return would be around 19%.

If the pasture lasts 25 years, the net present value (NPV 10%) of this system would be around $394/ha, while the internal rate of return would be around 19.6%.

- For a ***saltbush and inter-row pasture system***, costing:
  - $670/ha to establish (including site preparation, seed, fertiliser, weed control, fencing, water points);
  - $15/ha for annual maintenance (fertiliser, weed control); and
  - $40/DSE capital value of extra livestock (the cost of purchasing DSEs to utilise the extra feed).

  With 18 months of grazing foregone during establishment, gross margins of $25/DSE and a pasture life of 20 years, the landholder would need to maintain a stocking rate of 9 DSE/ha for at least 7 years to break even. Over the 20 years of the investment (maintaining a stocking rate of 9 DSE/ha/yr) the net present value (NPV 10%) would be around $515/ha, while the internal rate of return would be around 16.5%.

These profitability calculations do not include whole farm benefits that come through improved control of paddock use, improved weed control, higher land value and other benefits as discussed in Section 2.1.

Case studies (see Section 13) provide further examples of economics analyses.

3 HOW DO I SELECT THE RIGHT PLANTS?

Key points:

- Plant and landscape indicators combined with soil salinity measurements can be used to indicate appropriate pasture species.
- Salinity and waterlogging conditions will fluctuate through the year – there may be seasonal niches for higher productivity species (see Section 7.2).
- Other site factors (eg. patterns and amount of rainfall, soil texture, pH, sodicity, toxic elements, etc) can also determine which species will survive and thrive (see Section 4 'What do I need to know about my site?').
- Salinity has been broadly mapped in South Australia, with 7 classes of salinity. This mapping and land classification system is also a useful guide to appropriate pasture species (see Section 7.3).
- Saltland treatment and use must be guided by the capability of the land. Higher capability saltland (ie. less salty) can grow more productive species. But it may be possible to improve the capability of saltland through mitigation works (eg. drainage) [see Section 4.1 & Section 6.1.3].
- Networks such as the SGSL network (involving producers, researchers & extension workers) are valuable in raising awareness of options & opportunities for saltland pasture development.

3.1 A STEP BY STEP APPROACH

To identify appropriate saltland pasture species for your site the following steps are recommended, as outlined in Table 1.

Table 1. Recommended steps to select appropriate saltland pasture species.

Step	Action	Comments
Seek guidance		
	1. Seek local knowledge and experience. Attend field days. Contact farmer groups or agronomic consultants. See what's going on in your area. See examples of success relevant to your site.	(Also see 'Contacts & websites' section, page 133)
Look at site conditions		
	2. Understand your site conditions, including:	(Also see Section 4)
	• Soil salinities, using at least:	
	o Indicator plants, and	
	o Soil salinity ECe tests.	(Section 7)
	• Soil salinity variations across the paddock and through the year.	(See Sections 7.1 to 7.5)
	• Likely levels of inundation and waterlogging (months per year).	

	• Ability for a perennial species to persist. • Soil pH, fertility status, texture and depth. • The nature of the country (flat or undulating). • Seasonal patterns and total annual rainfall. • Whether saltland will be managed separately (preferable) or as part of a larger paddock. • Which areas are likely to be productive, and which aren't.	
	3. Assess scope for improving site conditions: • Consider fencing to land class. • Consider salinity mitigation works (eg. drainage).	(Section 6.1.3)
Look at plant information	**4.** Use the information / tools in this manual as a guide to where various plant species are suited:	
	• 'Guide to plant salinity and waterlogging tolerances'.	(Section 3.2, including Figure 2 & Table 2)
	• 'Saltbush or salt-tolerant perennial grasses?'	(Section 3.3)
	• 'Relative tolerance of crops and pastures to soil salinity'.	(Figure 3, page 17)
	• 'Indicative salinity levels & capability of saltland'.	(Table 13, page 83)
	5. Compare your saltland to the 'Examples of saline landscapes & productive pasture options'.	(Section 8)
	6. Investigate the prospects in your region for different saltland pastures.	(Section 9)
	7. Create a list of potential pasture species (for now, based on salinity and waterlogging conditions).	
	8. Check other preferred conditions for the shortlisted plants (eg. soil type, pH, rainfall, etc.) Refer to Section 5 'Introducing the major saltland pasture species', or other sources.	(See Section 5, or other sources)
Consider management issues	**9.** Consider relevant management issues, eg: • Seasonal timing of grazing and regrowth. • When high grazing pressures may be required (eg. for tall wheat grass in late summer). • Managing mixed pasture systems. • Weed potential of species.	(Management information is contained in Section 6) (Cattle would be required if rank tall wheat grass requires grazing.)
Create a final shortlist	**10.** Decide on the best bet pasture species.	
Estimate profits	**11.** Use the 'profitability calculator' to estimate the profitability of your saltland system.	(See Section 12 'Tools for estimating profitability')
Conduct a small-scale trial if necessary	**12.** Trial work should factor in recommendations for large-scale establishment, including: • Use seed that has been germination tested. • Use a 'shotgun mix' in variable country. • Don't sow in bad years.	(See Section 6, 'Establishment & Management')

3.2 GUIDE TO PLANT SALINITY AND WATERLOGGING TOLERANCES

In saline landscapes, the levels of salinity and waterlogging are major factors in deciding which plants will grow. Many other factors will dictate the suitability of a species (eg. soil texture, pH, rainfall, inundation, etc.) but knowledge of salinity and waterlogging tolerances will provide a useful first cut for short-listing potential pasture species for your site.

TOOL

Figure 2 provides a guide to the relative salinity and waterlogging tolerances for a number of important saltland plants. These are broadly categorised into:

- Saltland weeds and indicator species,
- Halophytic shrubs (saltbushes, bluebush and samphire),
- Salt-tolerant perennial grasses (including puccinellia and tall wheat grass), and
- Species for higher capability saltland.

This figure shows graphically that there is considerable overlap between the tolerance ranges of various species. In particular, at low to moderate salinities more than one species is likely to be suited to your site. However there are fewer options available as salinity levels increase. The information contained in Figure 2 is partly presented in text form in Table 2.

Figure 2 should be viewed along with the salinity level (class) definitions shown in Table 13 (Section 7 ‘Measuring salinity’, page 83) and the images of saltland in Section 8 ‘Examples of saltland & productive pasture options’.

Figure 3 shows more detailed information on salinity tolerances for selected plant species.

3.3 SALTBUSH OR SALT-TOLERANT PERENNIAL GRASSES?

When they can work together

There is considerable overlap in the conditions suited to both saltbush and perennial salt-tolerant grasses. They can work well together, for example where saltbush is used to lower or control watertables, making conditions suitable for a higher productivity understorey than would otherwise be possible. This understorey can include salt-tolerant perennials and/ or salt-sensitive short growing season annuals.

When establishing saltbush, livestock production will be maximised where an understorey of clovers/ medics or salt-tolerant perennial grasses can also be established.

When conditions favour one or the other

Notwithstanding this potential overlap, there are situations where one or the other will work best.

In general, saltbushes:

- are more suited to < 450 mm rainfall zones, and cope better with drought;
- do not like waterlogging for extended periods; and
- are more productive in warmer climates.

In general, salt-tolerant perennial grasses:

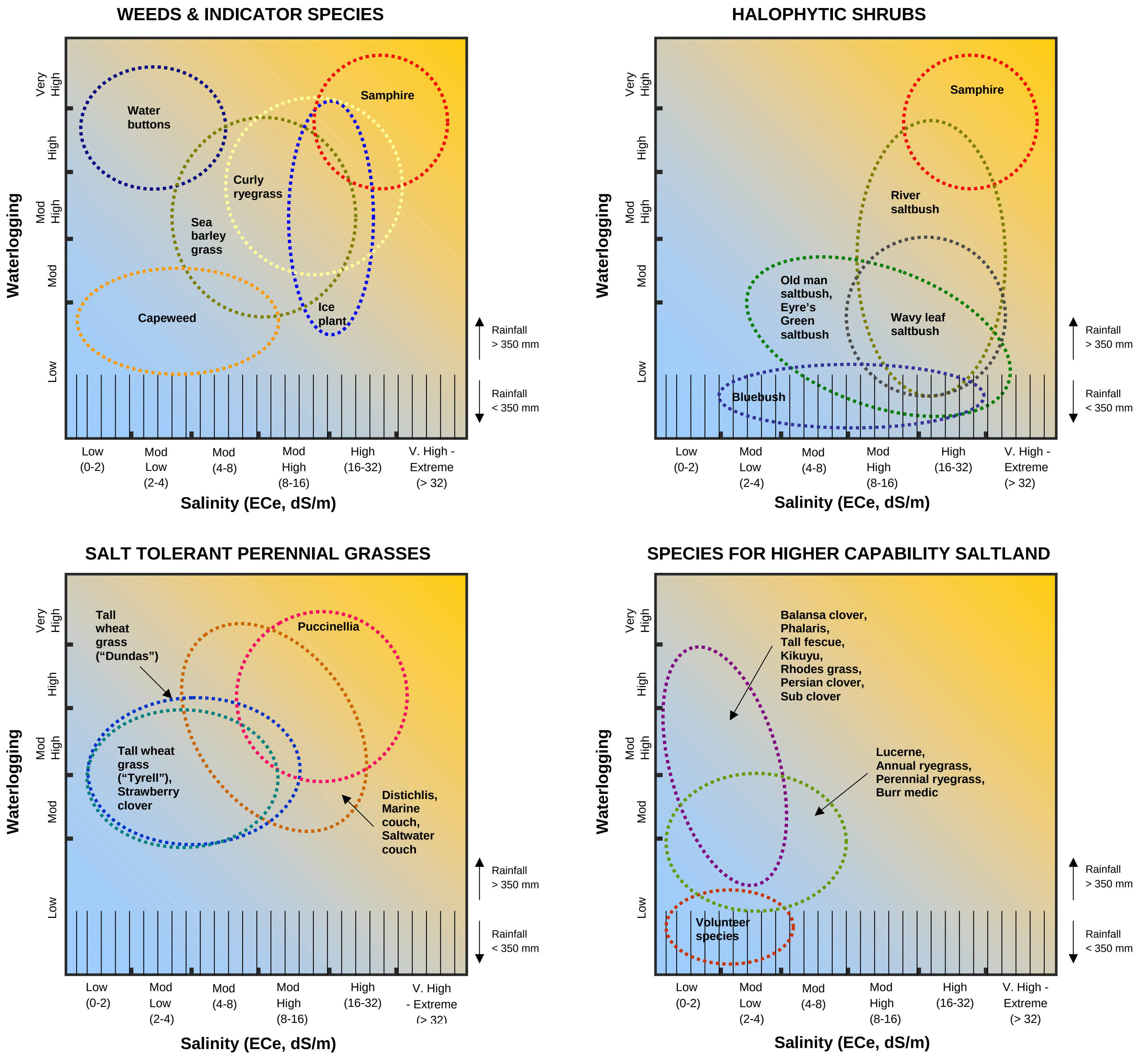
- are better suited to > 350 mm rainfall zones (with higher rainfall requirements for a number of species);
- can tolerate higher levels of waterlogging; and
- are more productive in colder climates.

Table 2. Broad guidelines for the selection of pasture species – on the basis of rainfall, salinity & waterlogging tolerances (adapted from Herrmann, 1995). [Also see Figure 2]

	Salinity Level			
	Low – Moderate	**Moderately High**	**High**	**Very High - Extreme**
Rainfall & period for which the soil is saturated to the surface each year	***Vegetation & Landscape Indicators***			
	Annual ryegrass & sea barley grass	**Complete sea barley grass**	**Patchy sea barley grass** **Patchy scalding** **Some samphire**	**Samphire** **Bare scalds**
Less than 350 mm	Old man saltbush Small leaf bluebush	Old man saltbush Small leaf bluebush	Old man saltbush Small leaf bluebush	**Old man saltbush
***Over 350 mm**	Tall wheat grass Phalaris Tall fescue Frontier balansa clover Old man saltbush Annual ryegrass	Puccinellia Tall wheat grass Old man saltbush River saltbush Wavy leaf saltbush	Puccinellia Old man saltbush River saltbush Wavy leaf saltbush	**Old man saltbush **Puccinellia
***Over 350 mm; Soil saturated for 1-3 weeks**	Tall wheat grass Perennial ryegrass Phalaris Tall fescue Frontier balansa clover Strawberry clover Old man saltbush	Puccinellia Tall wheat grass River saltbush Wavy leaf saltbush Old man saltbush	Puccinellia River saltbush Wavy leaf saltbush	**Puccinellia **Samphire
***Over 350 mm; Soil saturated for 1-3 months**	Tall wheat grass Perennial ryegrass Phalaris Tall fescue Frontier balansa clover Strawberry clover	Puccinellia Tall wheat grass River saltbush	Puccinellia River saltbush	**Puccinellia **Samphire

Notes:

- ***MINIMUM RAINFALL REQUIREMENTS:** puccinellia > 350 mm, phalaris > 400 mm, tall wheat grass > 425 mm, Frontier balansa clover > 450 mm, strawberry clover > 500 mm, tall fescue > 600 mm, perennial ryegrass > 600 mm. As salinity levels increase, minimum rainfall requirements may also increase. Moisture from the watertable may partly offset rainfall requirements in some species (eg. strawberry clover).
- Site conditions such as rainfall, soil type and pH need to be considered further.
- Waterlogging reduces the survival of saltbush.
- Eyre's Green saltbush is a cultivar of old man saltbush (selected for improved palatability) and is likely to have similar tolerance ranges.
- **For 'Very High – Extreme' salinity, primary salinity areas should be returned to their natural state (see Important Notes in Section 6.1.2). In secondary saline areas, productivity is usually severely limited. The profitability of developing these areas is questionable. Recommend production from volunteer species only, or manage for environmental values.
- This guide includes information from a variety of sources and requires further validation.



Salinity Legend

Salinity Level*	Topsoil peak ECe (dS/m)
Low (non-saline)	0-2
Moderately Low	2-4
Moderate	4-8
Moderately High	8-16
High	16-32
Very High - Extreme	> 32

* Also see salinity level definitions in Table 13, Section 7.3.

Waterlogging Legend

Waterlogging Level	Soil conditions
Low	Soil saturated up to 1 week
Moderate	Soil saturated up to 1 month
Moderately High	Soil saturated up to 2 months
High	Soil saturated up to 3 months
Very High	Soil saturated over 3 months

Notes:

- The shapes provide a rough guide to salinity and waterlogging tolerances. Where multiple species are listed, the shapes envelope the various tolerance ranges of the species but may not accurately represent an individual cultivar.
- Salt and waterlogging tolerances will vary depending on the stage of plant development (eg. germination v's mature plants).
- Different cultivars of a species may have different tolerance ranges.
- A range of other factors will need to be considered when selecting plants, eg. soil texture, pH, rainfall, etc.
- Areas below 350 mm rainfall are generally not suitable for establishing saltland pastures, excepting saltbush or bluebush. Volunteer species may provide additional grazing production.

Figure 2. Guide to salinity and waterlogging tolerances for selected species (adapted in part from Barrett-Lennard et al. [2003] and Herrmann [1995]).

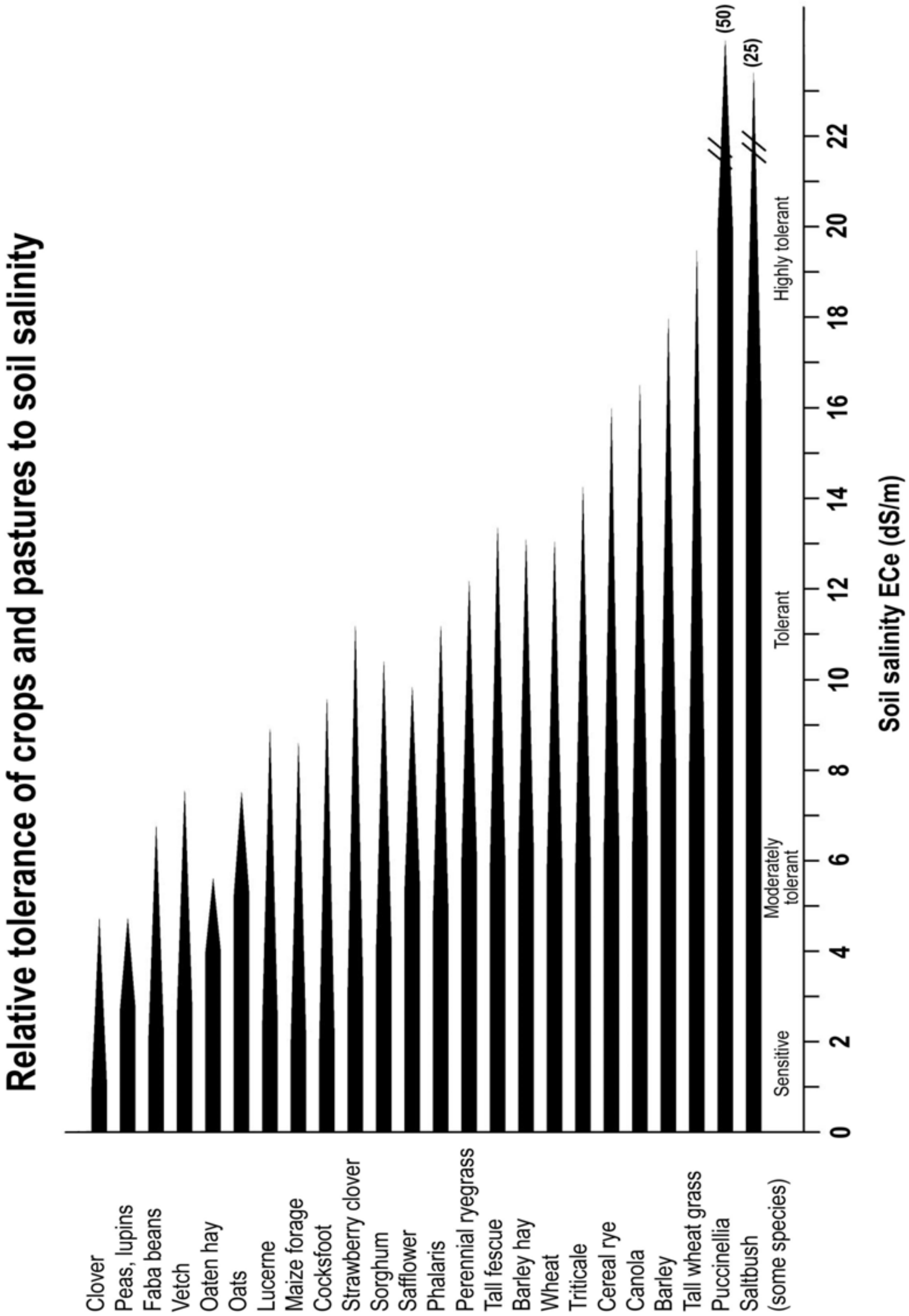


Figure 3. Relative tolerance of crops and pastures to soil salinity (from Herrmann, 1995).

Notes:

- This chart indicates when crops begin to be affected by soil salinity (narrowing of the bar) and when yield is reduced by 50% (end of bar).
- Tolerance to soil salinity is reduced for seedlings and under waterlogged conditions.
- This figure uses ECe (dS/m) values. To obtain approx ECe values from EC 1:5 values refer to Section 7.5.
- Waterlogging status (among other factors) will also determine species suitability for a site (see Figure 2).

Table 3 summarises a number of important considerations for landholders looking at either saltbush or salt-tolerant perennial grasses, and how they might play a role in their saltland grazing system.

Table 3. Saltbush or salt-tolerant perennial grasses?

	Pros	Cons
Salt-tolerant perennial grasses (eg. puccinellia, tall wheat grass)	Easiest and cheapest to establish. High productivity perennials. Produce high quality fodder. Puccinellia tolerates high salinity and waterlogging. Tolerant of hard grazing once established. Easily fits into established grazing system. Can provide good cover on ground to reduce evaporative concentration of salts over summer.	Not suitable in low rainfall areas (< 350mm). Nitrogen fertiliser required for maximum production (where legumes don't persist at higher salinities). Tall wheat grass requires strategic grazing management to avoid becoming rank, unpalatable, and poor quality feed. Some feed supplementation may be required (eg. with declining feed quality of puccinellia over summer-autumn).
Saltbushes	High water user - can help to lower watertable. Generally long-lived perennials. Species available for low rainfall areas. Relatively drought resistant. Can be established in alleys with more productive grasses/ legumes sown as understorey. Planting density can be adjusted to site conditions. Higher densities at higher salinity. Less dense saltbush & more inter-row pastures as conditions improve. Provide a good risk management strategy – controlling watertables while providing productivity. Produce high protein forage. In general, do not require fertiliser.	Do not tolerate excess waterlogging. More expensive to establish than grasses. Direct seeding can be unreliable. Stricter grazing management required. Stock require ample fresh water. Feed supplementation required to maintain energy requirements. May contain toxic compounds (eg. oxalates) which are dangerous for animals at high doses. Not as productive as grasses in cooler climates.

4 WHAT DO I NEED TO KNOW ABOUT MY SITE?

Key points:

- A range of site conditions (eg. salinity, waterlogging, soil types, pH, rainfall, topography, etc.) combine to influence the type of plants that can be grown, and the resulting levels of animal production.
- It is important to know your country and work within its limitations.
- On sites with fewer limitations (ie. high capability saltland) development can significantly improve production.
- Sites with extremes of salinity or waterlogging, or other limitations, (ie. low capability saltland) have limited potential for development.
- Mitigation works (eg. drainage) may improve production potential.

4.1 SALTLAND CAPABILITY

Increasing salinity, along with other limitations, reduces the capability of land to grow productive pastures.

We can think about salt-affected ground as being somewhere in the range between:

'High capability' saltland

- Having highly favourable site conditions.
- Capable of supporting highly productive plants and high levels of animal production.
- Having high potential for improvement.

and

'Low capability' saltland

- Having poor site conditions.
- Capable of supporting poorly productive plants and low levels of animal production.
- Having low potential for improvement.

4.2 SITE CONDITIONS

The type of plants that can be grown (and the resulting levels of animal production) not only depend on soil and groundwater salinity but also conditions such as the extent and duration of waterlogging and inundation, patterns and quantity of annual rainfall, soil texture and chemistry, and topography.

Different plants (and weeds) can cope with different conditions. Unfavourable site conditions can cause reduced productivity or plant death. Conversely, appropriate species can be identified by comparing site conditions to known tolerance ranges for different species.

A range of site conditions are discussed below. It is the combination of these conditions (rather than any single condition) that will determine if an environment is suitable for a particular saltland plant.

Salinity

Salinity refers to the presence of dissolved salts in soil and water. Salinity can be natural (‘primary’ salinity) or due to human-induced changes (‘secondary’ salinity).

Primary salinity dominated sites are characterised by naturally very high to extreme salinity, salt-tolerant vegetation and/or bare scalds. The salinity in these sites is historical, being present prior to the development of the land for agricultural purposes. These areas will have poor productive potential and should be left in their natural state to be managed for environmental values. It should be noted that native vegetation (including samphire), on either primary or secondary salinity sites is protected under the *Native Vegetation Act 1991* – as discussed in Section 6.1.2, page 46.

Secondary salinity dominated sites occur where degradation has been largely caused by land use change. The term ‘dryland salinity’ is commonly equated with secondary (human-induced) salinity associated with shallow watertables, in non-irrigated areas. These areas are the focus for establishing saltland pastures (to help reclaim significant areas of the farm that otherwise appear lost to salinity), and hence the focus of this manual.

Salinity can vary across the paddock, through the year and between years (see Section 7.2). Appreciating this variability in both space and time can reveal opportunities for gains in production. For example seasonal salinity reductions (as salts are flushed with winter rainfall) can provide a window of opportunity for short growing season legumes (eg. Frontier balansa clover, Scimitar or Santiago burr medics).

Salinity mapping

Areas dominated by primary (natural) and secondary (clearing-induced) salinity have been mapped across the agricultural regions as indicated in Figure 4. This mapping was conducted by the Department of Water, Land and Biodiversity Conservation Soil and Land Program (DWLBC SaLP).

Defining and measuring salinity

Different levels of salinity, units and methods of salinity measurement are discussed in Section 7 ‘Measuring salinity’.

Types of salinity

It should be noted that there are different types of salinity, which occur with or without the influence of groundwater. This manual is principally concerned with saltland pasture systems for areas that are affected by groundwater discharge from shallow saline watertables, and many of the species discussed are able to make productive use of the soil moisture that rises from shallow groundwater.

Some of the saltland pasture species discussed may also be suited to another major type of salinity, ‘dry saline land’, which occurs without the influence of groundwater. Different salinity types (irrigation, dryland and dry saline land) are further discussed in the Glossary.

Rainfall

Seasonal patterns and total annual rainfall are important factors in determining salinity levels and appropriate species for a site. Long-term average annual rainfall zones are shown in Figure 5, however potential climate change may alter this picture in the future.

In wetter areas, salts tend to be diluted and flushed from the landscape (subject to landscape drainage), and plants often require greater waterlogging tolerance.

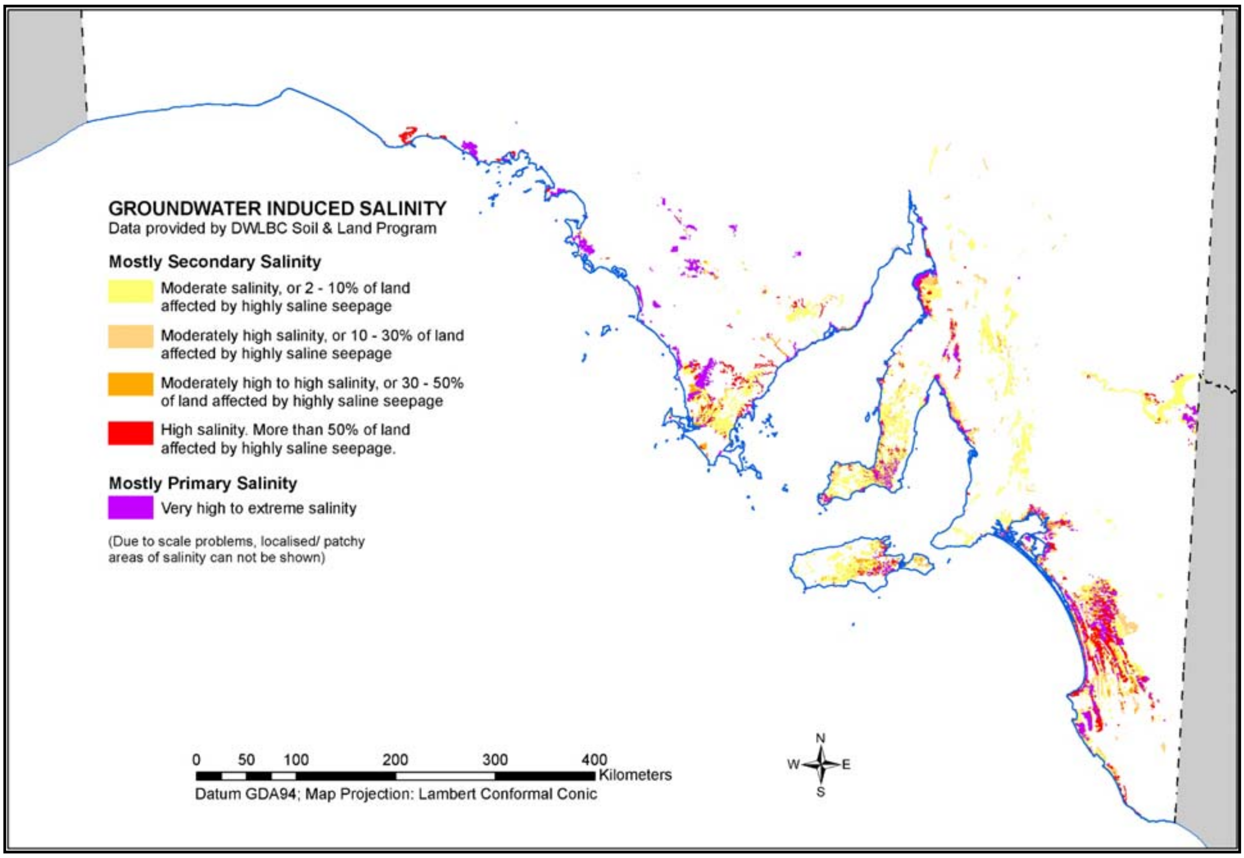


Figure 4. **Areas dominated by primary (natural) and secondary (clearing-induced) salinity.**

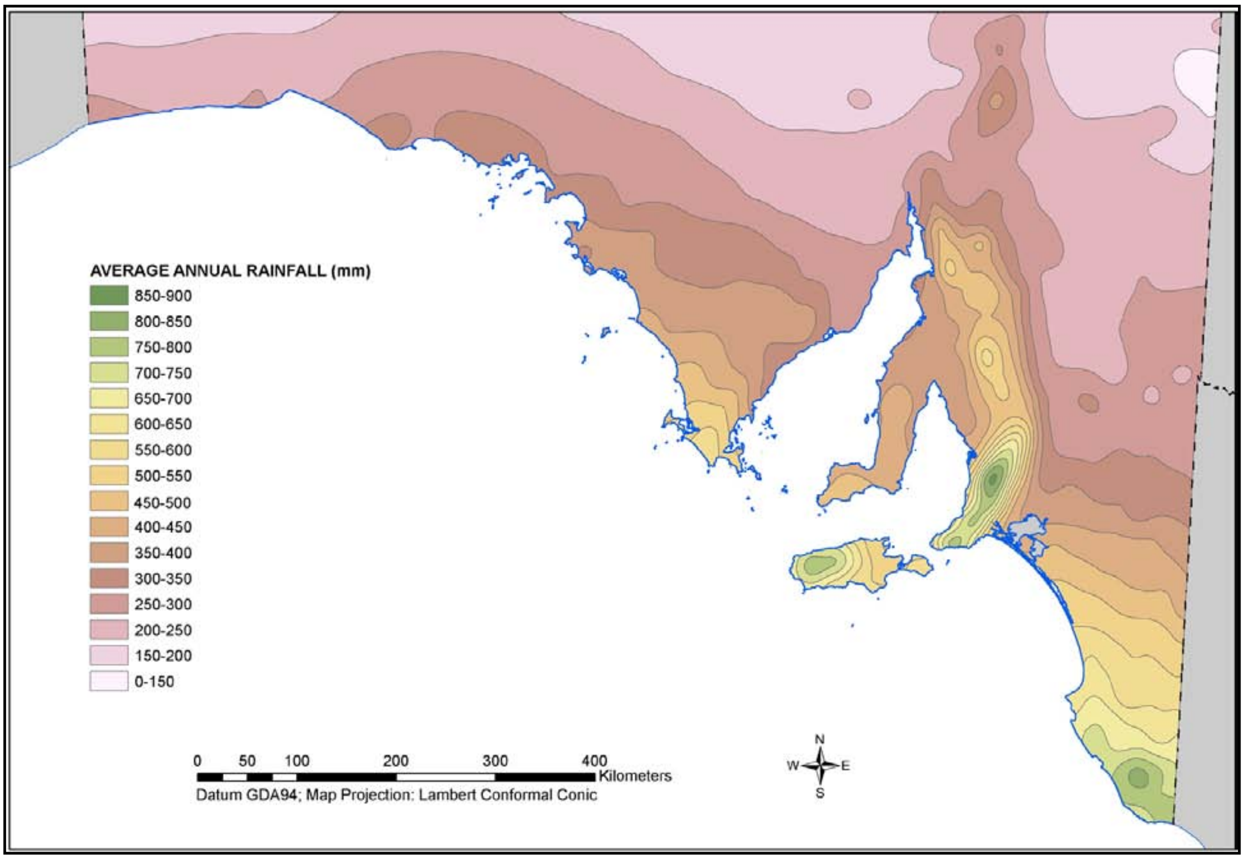


Figure 5. **Rainfall zones in the agricultural areas of South Australia.**

In drier areas, evaporation can have a larger influence than rainfall and salts tend to concentrate. Plants generally need to be more salt and drought tolerant.

Annual rainfall levels can also provide an indication of the upper limits of productivity, assuming that pastures are capable of using all the rain that falls. In South Australia our rainfall predominantly falls in the winter months, however summer storms are known to bring significant falls in some areas. Saltland pasture plants are adapted to a range of different growing seasons and can use rainfall directly or indirectly (through accumulated groundwater).

Groundwater flow system (GFS) type

Knowledge of GFS type (also see the Glossary) is essential for determining the focus for salinity management (eg. recharge control or living with salt). GFS usually determine the severity and scale of salinity, which directly affect the suitable saltland pasture options and the scale of establishment.

The most severe salt (in severity and extent) is usually associated with discharge from broad, flat ‘regional’ groundwater flow systems. These collect groundwater from large areas, over long periods of time. These systems are the most difficult in which to reverse salinity trends. Therefore living with salt, through the establishment of saltland pastures, is a high priority.

Fresher and more localised discharge is often associated with quicker flowing, more hilly, ‘local’ GFS which collect groundwater from smaller catchment areas. In local GFS, salinity levels are expected to be relatively fresh (unless associated with deeply weathered sluggish clayey sediments) and discharge will occur in smaller, more localised areas. Because areas of saline discharge are smaller, saltland pastures may need to be managed in the same paddock as other more traditional (non-saline) pastures. Local GFS are also easier to remediate through catchment recharge reduction and other salinity management options. Somewhere between ‘regional’ and ‘local’ scale GFS are ‘intermediate’ flow systems.

Some sites may experience groundwater discharge resulting from interactions between deeper, larger scale flows, and shallower, more local groundwater flows.

Waterlogging

Waterlogging (saturation in the plant root zone) typically reduces plant vigour, exacerbating the impacts of salinity. It is influenced by a combination of rainfall, soil type and landscape drainage. As rainfall increases, salinity levels may decline but the likelihood of waterlogging impacts will increase.

Inundation (flooding)

Inundation restricts gas exchange in aerial plant tissues and even short periods can be highly damaging. There are few species that will cope with flooding for extended periods. Puccinellia is a major exception. In the Upper South East where salinity declines markedly with winter rainfall, it actually appears to benefit from flooding, provided the plant is not fully submerged and surface water is managed to prevent stagnation (pers. comm. James Darling, Upper South East saltland farmer).

Landscape drainage

If surface water and/or groundwater cannot get away, salinity and waterlogging problems are sure to follow. Low-lying, flat areas (often depositional areas that have accumulated finer/ clayey materials) are more prone to inundation with surface water, as well as adverse impacts from shallow saline groundwater.

Soil type

Soils influence vertical and lateral drainage, and the degree to which moisture and salts are drawn up from underlying groundwater through capillary action. Heavier clay soils draw and retain moisture and salts, are more prone to waterlogging, and more resistant to flushing of salts with rainfall. In comparison to sands or loams, heavy clay soils can also:

- impede rates of plant transpiration and growth,
- delay germination at the beginning of the season, and
- bring on an early finish to the season.

pH

pH levels may restrict pasture choice, or limit productivity in some species (eg. puccinellia and lucerne do not like acid soils). In some cases it may be cost effective to adjust pH levels (eg. incorporating lime to ameliorate acidity).

In some areas rising saline watertables have altered the pH of soils. In the Upper South East it has been reported that areas which were typically low pH (acid) sandy soils, have after years of saline discharge, become very high pH (alkaline) soils due to sodium carbonate in the groundwater. Such conditions can be inhospitable to a large range of pasture species.

Other soil factors

A range of soil factors should be considered when looking to establish saltland pastures. Aside from those already mentioned, these include: fertility (major nutrients and trace elements), sodicity, toxicity (eg. high boron) and soil profile (encompassing soil type and soil depth).

Soil factors may:

- influence the species of saltland plants that are able to survive and/or thrive, or
- represent limitations to plant productivity.

Where limitations can be addressed, it may be possible to grow a wider range or more productive saltland pasture species. Boosting productivity (and hence water use) can also help alleviate the severity of salinity in some areas.

The salinity mapping shown earlier is only one attribute from a large number of soil attributes that have been mapped by the Department of Water, Land and Biodiversity Conservation. This mapping provides valuable information on potential crop and pasture limitations throughout the agricultural areas of the State. Further information is available from the DWLBC website, see:

LINK

www.dwlbc.sa.gov.au/land/soil/products/index.html [or refer to DWLBC fact sheet 12, on the CD-ROM]

Potential mitigation works

More productive species may eventually be established (than initial site conditions would suggest) if mitigation works can be undertaken. These may include (where appropriate):

- Shallow (surface water) drainage/ management to alleviate seasonal flooding or prevent stagnation of floodwaters.
- Groundwater drainage to lower watertables.
- Ameliorating soil limitations (eg. fertility, acidity, sodicity).

These issues are discussed in more detail in Section 6.1.3 ‘Site preparation – mitigation works’.

4.3 OTHER SALINITY MANAGEMENT OPTIONS FOR THE FARM

Saltland pastures are often just part of the picture. They are a means of living productively in saline discharge areas. But addressing the salinity problem also means looking at the cause of salinity: poor water use from shallow rooted crops and pastures.

Depending on your terrain and geology, groundwater can accumulate from regional or local scales to cause a problem on your place. Regardless, the main actions for landholders to tackle salinity will be the same. Aside from living with salt (ie. establishing saltland pastures), these are:

- to make the most of the rainfall where it falls, and
- prevent the water from accumulating in problem areas.

Higher water use means higher plant production, while also reducing localised inputs to the salinity problem. Aside from establishing salt-tolerant pastures, a range of activities will help to address salinity and boost production:

- Clay spreading on sandy, and non-wetting, soils (including sandhills) and delving in sand over clays.
- Establishing deep-rooted perennials such as lucerne, primarily on recharge areas of low to moderately low salinity.
- Improving drainage (as discussed in Section 6.1.3), with due consideration to downstream landholders and conservation wetland areas.
- Revegetation for recharge control and environmental values.

5 INTRODUCING THE MAJOR SALTLAND PASTURE SPECIES

5.1 MAJOR SYSTEMS FOUND IN SOUTH AUSTRALIA

The major productive saltland pasture systems found in South Australia can be summarised as follows:

- Saltbush + volunteer understorey (< 350 mm rainfall).
- Saltbush + sown understorey (350-450 mm rainfall).
- Tall wheat grass based pastures (> 425 mm rainfall, moderate salinity/ moderate waterlogging areas).
- Puccinellia based pastures (> 350 mm, moderate to high salinity/ moderate to high waterlogging areas).
- Species for higher capability saltland (these are annual and perennial pastures for low to moderate salinity, or seasonal reductions in salinity, > 350 mm rainfall).

Additional annual and perennial pasture grasses and legumes may form part of each of these systems where advantageous soil / environmental conditions occur.

5.2 OVERVIEW OF SALTLAND PLANT GROUPS

The plants that grow on saltland can be broadly grouped, as shown in the table below. The major species applicable for South Australia and their saltland niches are described in the sections that follow.

Table 4. Major saltland plant groups.

Group	Examples	General comments
Samphires	*Halosarcia* species	Salinity and waterlogging tolerant but have low value for production.
Saltbushes	Old man saltbush River saltbush Wavy leaf saltbush	Some variation between species, but generally suited to lower rainfall, higher salinities, and low to moderate waterlogging. Variable palatability and variable recovery from grazing.
Bluebush	Small leaf bluebush	Suited to low rainfall, non-waterlogging conditions.
Salt-tolerant grasses	Puccinellia Tall wheat grass	Suited to moderate and higher rainfall, saline and waterlogged conditions.
Other legumes & grasses	Balansa clover Phalaris Tall fescue	Higher productivity, but suited to lower salinity conditions. Variable tolerances to waterlogging.

About the plant information that follows…

The publication ***"Saltland Pastures in Australia: a practical guide"*** (Barrett-Lennard et al., 2003) provides a valuable summary of the most useful saltland species. It draws on many experiences from Western Australia, but also contains a wealth of broadly applicable information. As such, this document has provided a major source of information for this section – which provides introductory information for the major productive species for saltland areas.

Saltland pastures should be composed of diverse and interacting species in order to make full use of rainfall and groundwater, and provide better overall feed quality.

It is hoped that future saltland pastures will comprise a wider range of species than is presently used, as ongoing field studies uncover greater numbers of potential species.

Images depicting many of the following saltland species have been taken from ***"SALTdeck"*** (Anon, 2006), a series of cards outlining the values, salinity and waterlogging tolerances and identification information for a range of saltland species. [*SALTdeck* can be ordered by phone from CanPrint Communications on 1800 776 616 - quote product number PB 061190, or from www.landwaterwool.gov.au or www.crcsalinity.com.au .]

Caution!

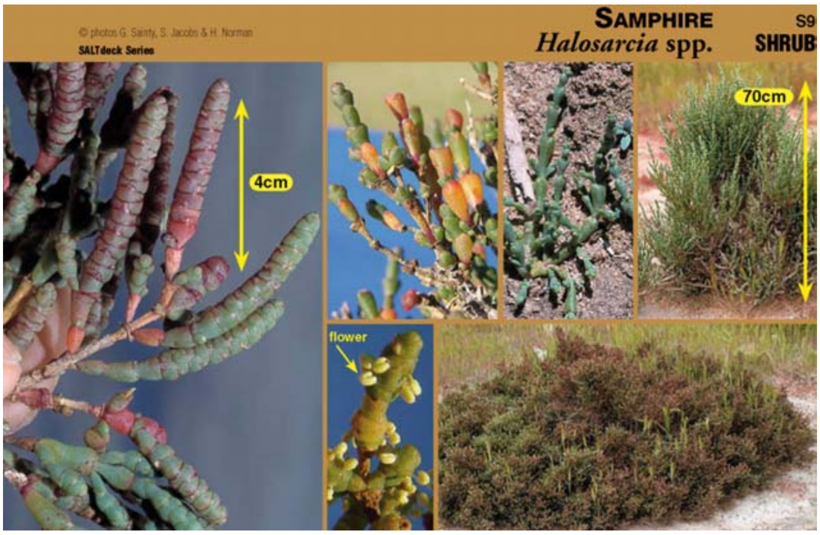
For some species discussed in this section, information may be lacking on the performance and plant requirements under South Australian conditions. Plant information may have originated from interstate or other regions of SA (indicated where possible) and these plants may not perform exactly the same on your property. In more salt sensitive species (discussed in Section 5.5), minimum rainfall requirements may increase as salinity levels increase.

5.3 HALOPHYTIC SHRUBS

Samphire (Halosarcia species)

Samphires are the most salt and waterlogging tolerant plants but they have low productivity and high oxalate content. They are of <u>low value for grazing</u>.

They may occur naturally (primary salinity areas) or colonise highly saline secondary sites.



SALTdeck card series (Anon, 2006)

Saltbushes – general information

Characteristics for a wide range of saltbushes are contained in Table 5, while selected species are featured in more detail in the text that follows. Guidelines from Western Australia suggest that saltbush should only be grown in areas receiving between 300-450mm annual rainfall. Saltland sites with higher rainfall will generally be too waterlogged for saltbush.

Ideally, saltbush growing on saltland should be supplemented with low salt hay, stubble, understorey pasture, or grain, in order to meet livestock energy requirements. On its own, saltbush is a maintenance forage for sheep. It has relatively low digestibility (46-62%) and high mineral/ salt concentrations (17-33%). High salt levels reduce its value as a source of metabolic energy and limit feed intake as sheep can only ingest around 100 grams of salt per day. However saltbush leaves

Table 5. General characteristics of selected saltbush plants in South Australian conditions

Species	Common name	Size W*H (m)	Tolerance to Salinity	Tolerance to Waterlogging	Palatability	Grazing recovery	Ease to establish by direct seeding	ASuitability for 'dry saline' sites	Comments
Atriplex amnicola	River saltbush	2*1	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆	☆☆	Recommended for most situations. Highly productive. Can be difficult to establish from seed.
Atriplex undulata	Wavy leaf saltbush	1.5*1	☆☆☆☆	☆☆☆	☆☆☆	☆☆☆☆	☆☆☆☆	☆☆	Recommended for most situations. Productive and readily established from seed.
Atriplex lentiformis	Quailbrush	2.5*2	☆☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆☆?	Recommended as part of a mixture. Rapid early growth but shorter lived (6-10 years).
Atriplex cinerea (prostrate form)	Grey saltbush	5*0.5	☆☆☆☆	☆☆☆	☆☆☆☆☆	☆☆☆	☆☆	☆☆	Readily grazed and requires careful management. Spreading habit makes it ideal for covering bare areas.
Atriplex cinerea (upright form)	Coastal saltbush	3*2	☆☆☆	☆☆	☆☆☆☆	☆	☆	☆	Large woody shrub with rapid early growth. Readily eaten by stock but is unable to withstand heavy grazing.
Atriplex nummularia	Old man saltbush	1.5*2	☆☆☆☆	☆☆	☆☆	☆☆☆☆	☆☆	☆☆☆☆☆	Has a deep tap root and is very drought tolerant. Most productive for dry saline sites (eg. magnesia patches). Due to lower palatability it is best grown as a single species for better grazing management.
Atriplex nummularia "Eyres Green"	Eyres Green saltbush	1.5*2	☆☆☆☆	☆☆	☆☆☆	☆☆☆☆	☆☆	☆☆☆☆☆	Selection of old man saltbush for improved palatability and vigorous growth. From Eyre Peninsula.
Atriplex rhagodiodes	Murray River saltbush	2*1.5	☆☆☆☆ ?	☆☆☆ ?	☆☆☆☆ ?	☆☆☆ ?	☆☆ ?	☆☆ ?	Limited information suggests it has the potential to be a very productive shrub.
Atriplex semibaccata	Creeping saltbush	1*0.2	☆☆☆	☆	☆☆☆☆☆	☆	☆☆☆☆☆	☆☆☆☆	Good ground cover. Short lived (2-3 years) but readily regenerates from seed.
Atriplex paludosa	Marsh saltbush	1*1	☆☆☆	☆☆	☆☆☆☆	☆	☆☆☆☆	☆	Readily eaten by stock but unable to withstand heavy grazing, Easily established from seed.
Atriplex vesicaria	Bladder saltbush	0.5*0.5	☆☆☆	☆	☆☆☆☆	☆	☆☆☆	☆☆☆☆	Sensitive to grazing. Limited information suggests set stocking at low rates is an appropriate management strategy.
Atriplex bunburyana	Silver saltbush	1*1	☆☆☆	☆	☆	☆	☆☆☆☆	☆☆☆☆	Poor palatability. Unable to withstand heavy grazing.
Atriplex halimus	North African saltbush	1.5*2	☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆	☆ ?	Susceptible to insect/ disease attack.
Maireana brevifolia	Small leaf bluebush	1*1	☆☆☆	☆	☆☆☆☆	☆☆	☆☆☆☆	☆☆☆☆	Readily regenerates from seed. High quality feed but contains significant levels of oxalate.
Rhagodia parabolica	Rhagodia	1*1	☆☆	☆	☆☆☆ ?	☆ ?	☆ ?	☆☆☆	Understorey shrub. Unable to withstand heavy grazing.
Enchylaena tomentosa	Ruby saltbush	1*0.5	☆☆	☆	☆☆☆☆☆	☆☆ ?	☆☆☆ ?	☆☆☆☆	Small understorey shrub. Unable to withstand heavy grazing.

Key: ☆☆☆☆☆ = Very high; ☆☆☆☆ = High; ☆☆☆ = Moderate; ☆☆ = Low; ☆ = Very low.

Note: A – Dry saline sites include 'magnesia patches', and are not related to shallow groundwater.

[Adapted from information provided by Tim Herrmann, Rural Solutions SA] contain high concentrations of crude protein (up to 15%). The protein / nitrogen is accessible to stock provided adequate energy is available from other sources (Barrett-Lennard et al., 2003). Good quality stock water is also essential.

Saltbush can be very useful in high salt risk areas due to its high water use. Often it is planted in alleys, utilising saltbush to help control watertables, while improving conditions between the rows to allow more productive grasses and/or legumes to establish.

Where farmers are looking to establish saltbush on higher capability land (eg. where low salinity ground also occurs in paddocks with more saline ground), research from the Flora Search program (through the CRC Salinity) indicates that saltbush can provide high feed quality and useful dry matter production values. For example, in favourable conditions for old man saltbush, crude protein levels of 20-25%, digestibility of 75-80% and metabolisable energy of 11-11.8% have been measured (Hobbs et al., 2006a). Potential production from stands in low salinity areas of the Coorong Districts have been estimated at 4-5 tonnes dry matter/ha/yr (based on 1500 plants/ha) [Hobbs et al., 2006b].

River saltbush (Atriplex amnicola)

SALTdeck card series (Anon, 2006)

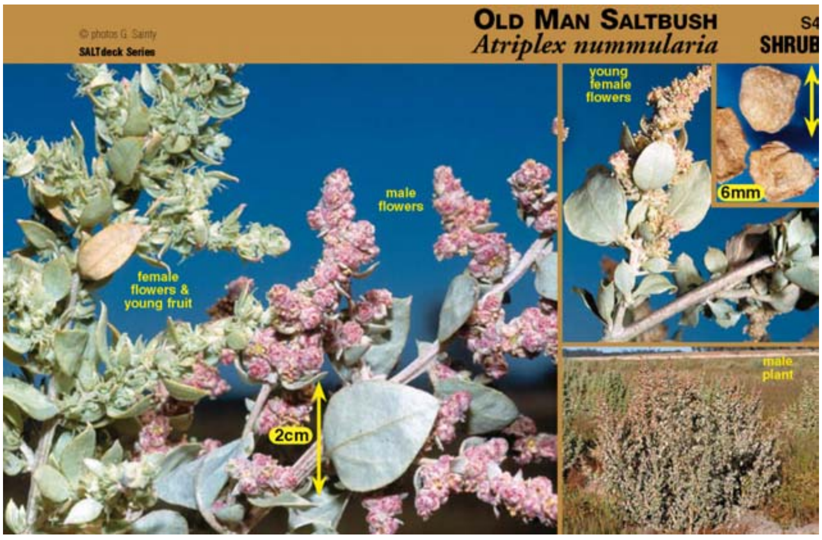
River saltbush is a large perennial shrub (usually 1m high by 1m wide, but up to 2.5m high by 4m wide) with shape varying between low spreading (prostrate) to upright (erect) forms.

It has moderate to high salinity tolerance, high drought tolerance and is rated highly in terms of long-term survival. Once established it can tolerate winter waterlogging, although prolonged waterlogging especially in summer will cause death.

It is a native of creeks and salt lake margins in parts of WA. It grows in areas receiving between 250-550mm annual rainfall.

River saltbush is palatable and recovers well from heavy grazing. It is an often preferred species on the basis of salt and waterlogging tolerance and good productivity.

Old man saltbush (Atriplex nummularia)



SALTdeck card series (Anon, 2006)

Old man saltbush is a perennial shrub with an upright/ erect growth habit, up to 2m high by 1.5m wide.

It is moderate to highly tolerant to salinity but has low to moderate tolerance to waterlogging. It is highly drought tolerant being a native of the semi-arid and arid zone of southern and central Australia. In the native state it is often associated with heavy soils or flood plains.

It grows well with annual rainfall ranging from 175-400mm.

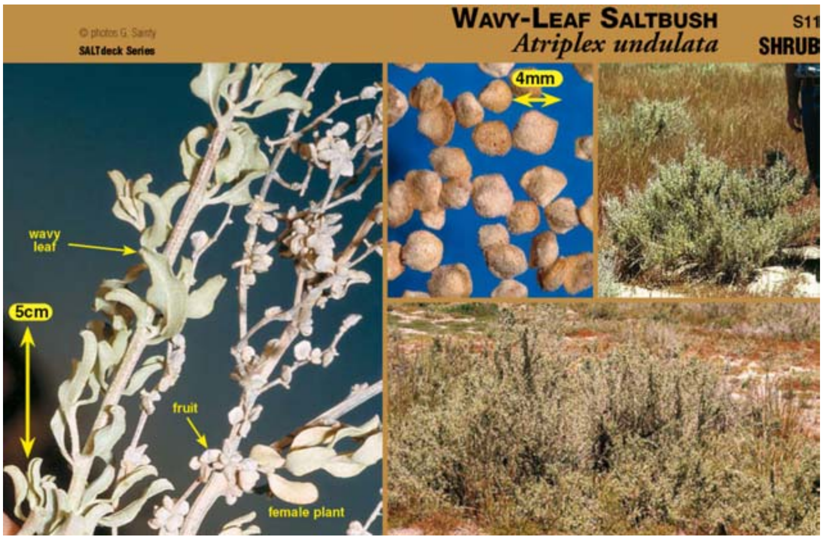
Old man saltbush has a lower palatability than some other saltbushes, although the varieties ‘De Kock’ and ‘Eyres Green’ are reported to have improved palatability. Eyres Green saltbush is a relatively recent cultivar of old man saltbush selected for improved palatability and vigorous growth. The original plant came from the Eyre Peninsula, hence the name.

Eyres Green saltbush

The upright growth habit of old man saltbush, relatively brittle branches and poor ability to produce volunteer seedlings are considered disadvantageous.

On the positive side it is deeper rooted than many other saltbushes and is very long-lived on soils not subject to waterlogging. In favourable conditions, landholders suggest it is capable of lasting 20-25 years or more.

Wavy leaf saltbush (Atriplex undulata)



SALTdeck card series (Anon, 2006)

Wavy leaf saltbush is a perennial shrub, up to 1m high and 2m wide, originating from the semi-arid rangelands of central Argentina. It grows well in areas receiving 250-500mm rainfall, but is not as waterlogging tolerant as river saltbush.

Individual plants do not tolerate repeated grazing but this species establishes readily from seed, and volunteer seedlings (from seed spread through animal faeces) often establish in large numbers following autumn grazing.

Wavy leaf saltbush is easier to establish by direct seeding than river saltbush but it is not as salt and waterlogging tolerant.

Small leaf bluebush (Maireana brevifolia)

SALTdeck card series (Anon, 2006)

Small leaf bluebush is a small perennial shrub that grows up to 1m high and wide.

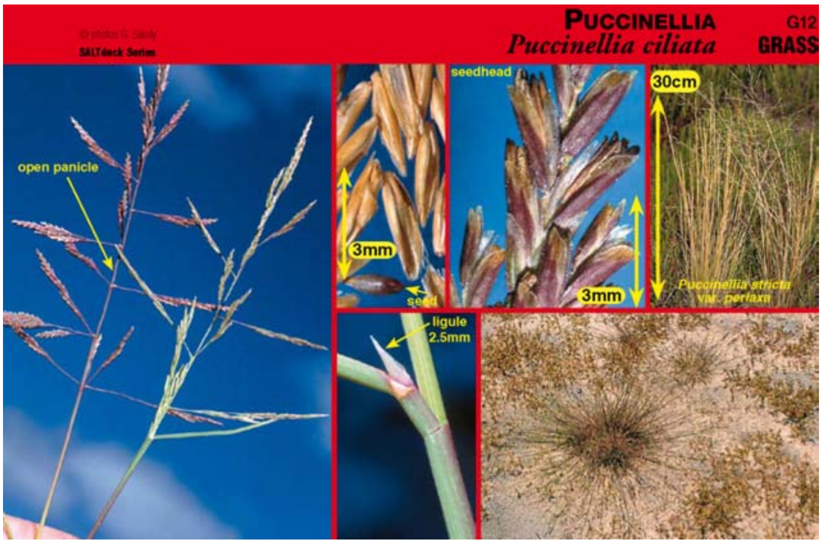
It grows well in areas receiving low rainfall (250-400mm). It is moderately to highly salinity tolerant, but has poor waterlogging tolerance. It will not withstand waterlogging or inundation for more than a few days.

Bluebush is high in oxalate (a toxic compound) and so should not be fed to sheep on its own. Many farmers regularly graze sheep on bluebush in summer to late autumn with pasture, stubble or hay in order to avoid poisoning by the oxalate.

The plant is high in protein, provides good grazing and recovers well. Small leaf bluebush is shorter-lived than some of the saltbush species but maintains a stand due to its excellent volunteering ability. It regenerates and spreads readily from seed.

5.4 SALT-TOLERANT PERENNIAL GRASSES

Puccinellia* *(Puccinellia ciliata)



SALTdeck card series (Anon, 2006)

Puccinellia is a perennial grass that is highly salt and waterlogging tolerant. Along with distichlis it is the most salt-tolerant of the commercially available grasses and the only salt-tolerant grass suitable for highly saline scalds that are dry in summer.

Puccinellia is highly palatable and has a low salt content. It forms tussocks up to 40cm high and wide and has long, thin leaves. Its growing points are embedded in the base of the plant, which is compact and resistant to grazing.

Puccinellia

The plants grow mid autumn to spring and mature (hay-off) in December, remaining dormant over summer to early autumn. Mature stands can be grazed after the opening rains (when they rapidly produce green feed) and/or more commonly as dry feed in late summer-autumn.

Leaving the feed standing over summer shades the soil, reducing evaporative concentration of salts in the surface soil. Puccinellia provides a beneficial feed option to sheep producers on saline land, in most instances providing a grass seed free pasture sward. Some landholders also successfully reap puccinellia seed in summer to autumn either for sale or on farm use.

Site suitability

Puccinellia is suited to slightly acid to highly alkaline, saline (ECe 10-50 dS/m), waterlogged soils, and is tolerant to prolonged periods of winter-spring inundation (more than 3 months) if properly managed (not grazing down so that plants become totally submerged). Some landholders report that puccinellia actually benefits from extended flooding, provided plants are not totally submerged and surface water does not stagnate. Anecdotal evidence indicates that protein content in autumn improves with longer durations of flooding (pers. comm. James Darling, Upper South East saltland farmer).

It is widely grown in this type of country in parts of Eyre Peninsula and the Upper South East. Puccinellia establishes on a range of soil types (sands to clays), providing ground cover on all but the most hostile of soils. Although establishment can be more difficult on heavier soil types.

It is suited to:

- areas that may be bare because of salinity and inundation,
- areas carrying sea barley grass, and adjacent scalded ground, where there is more than 350 mm rainfall,
- salt affected soils too waterlogged during winter for saltbushes, and
- areas that are often dry and saline in summer, but have minimal salinity in winter.

In variable landscapes it is often sown in a mixture with tall wheat grass and other species to optimise production from different niches in the paddock. Puccinellia colonises the more waterlogged/ higher salinity parts of the landscape and tall wheat grass occupies the less affected areas.

As land capability improves (with reduced salinity and waterlogging), puccinellia production is often limited by competition from other species. Its inability to compete strongly is mainly due to its slow early growth.

It can take up to 18 months before pastures on low fertility, highly saline sites are sufficiently developed to withstand grazing. However, puccinellia stands thicken up with time. Sparse stands can develop into dense swards within 5 years if properly managed. Fertiliser is important for boosting establishment and growth. Puccinellia spreads by seed through either wind or water movement. Colonisation of bare areas can be encouraged by roughening up the surface to catch the seeds.

Feed value

The grazing value of puccinellia depends on its stage of growth, a trait similar to most grasses. Green leaves from mid autumn to early spring have high protein content (15-25%) and high digestibility (60-75%), however this declines as the plant flowers and matures. It remains palatable in late summer and early autumn despite relatively low nutritive value (crude protein less than 5%, digestibility less than 50%). Mineral analysis has shown that several important nutrients and trace elements decline sharply over this summer-autumn period. Hence some feed supplementation with hay or grain is recommended to meet this seasonal shortfall in feed quality (also see Section 11.1). Puccinellia has a low salt content and makes good complementary feed for stock grazing high salt feed such as saltbush.

Average fertility pastures produce up to 5 tonnes of dry matter per hectare per year (up to 5-6 DSE/ha/yr equivalent). With appropriate management and use of nitrogenous fertiliser or companion legumes, yields of over 8 tonnes DM/ha/yr have been produced.

For further information see:

- Section 6.3 for establishment and management information.
- The brochure ***"Puccinellia: Perennial Sweet Grass"*** (Herrmann and Booth, 1997), available from PIRSA / Rural Solutions SA offices.

Tall wheat grass (Thinopyrum ponticum)

Tall wheat grass (TWG) is a spring/ summer active, clump-forming perennial grass suitable for areas of low to moderate salinity and waterlogging.

The plant has long bluish green leaves and can grow up to 2m high. Despite its upright growth habit, optimum feed qualities are achieved when pasture heights are maintained below 20cm.

SALTdeck card series (Anon, 2006)

Its summer activity makes it a useful species for supplementing the summer-autumn feed gap on farms. It is often sown in a pasture mix, with species such as puccinellia, strawberry or balansa clovers.

Site suitability

Tall wheat grass is successfully grown on low to moderate salinity (ECe: 0-16 dS/m), poorly drained, acid or alkaline soils. These soils are often dominated by sea barley grass, or occur on the margins of salt scalds. It may grow on sites with greater than 350 mm rainfall (with additional moisture from groundwater discharge), but ideally prefers greater than 425 mm.

Sites should be fenced and managed to prevent seed set, as tall wheat grass is an aggressive coloniser and will establish easily in non-saline areas. <u>It should not be grown where seed can spread into native vegetation, or where there is no intention to graze the site.</u>

It is widely grown in summer-moist areas and subsoil moisture (including capillary rise from shallow groundwater) or summer rain is required for good production. However it does not persist in areas that are waterlogged over spring and into summer.

Tall wheat grass is less tolerant of waterlogging than puccinellia. Where conditions permit, it is ideally suited as a companion plant to balansa clover to provide year round feed production.

In undulating (or variable salinity) paddocks, production can be optimised by sowing tall wheat grass with a mix of other perennial grasses (puccinellia, phalaris, tall fescue) and legumes (balansa clover, strawberry clover, persian clover). Tall wheat grass will colonise niche areas that are too saline for phalaris and tall fescue, but on slightly higher ground than would be suited to puccinellia. Its presence also reduces areas that might otherwise be colonised by silver grass or sea barley grass.

Cultivars

The most widely used cultivar in Australia is ‘Tyrell’, however a newer cultivar ‘Dundas’ (bred by Agriculture Victoria) has enhanced leafiness, palatability and feed quality. Anecdotal reports from within SA suggest that ‘Dundas’ also has slightly improved tolerance to salinity and waterlogging.

Feed value

Tall wheat grass grows actively from late spring onwards, while winter growth is poor. (Where suitable, balansa clover complements the tall wheat grass system by providing winter feed.)

Well managed tall wheat grass pastures provide highly palatable, good quality summer feed. Pastures are better suited to cattle, and heavy crash grazing encourages leafiness and helps maintain feed quality. Maintaining pastures under 20cm, through grazing or cutting, delivers optimum feed quality. When pastures are kept below 20cm, crude protein levels in spring can be as high as 19% with a digestibility of 75%. In contrast, for plants over 1m in height, feed quality drops significantly (crude protein 7.5%, digestibility 52.5%).

Feed quality declines in late summer, especially if the plant is left to grow rank with tall, mature and unpalatable stems. Seed set normally occurs from January to March. Stands require attention during this period to maximise feed quality, ensuring that plants aren't left to grow tall, rank and tussocky.

The ability of tall wheat grass to lower shallow watertables and decrease soil salinity can enhance the growth of companion legumes and other pasture plants.

Annual dry matter production is affected by the severity of salinity and management practices. Subsoil moisture over summer is also necessary for good production. In moderate salinity, typical pastures produce 3 to 4 tonnes of dry matter per hectare per year (4 to 5 DSE/ha equivalent). With appropriate management and application of fertiliser, yields can be doubled. Under favourable conditions, dry matter production yields of 12-13 tonne/ha and up to 17 DSE/ha/yr have been achieved in the South East* and Victoria.

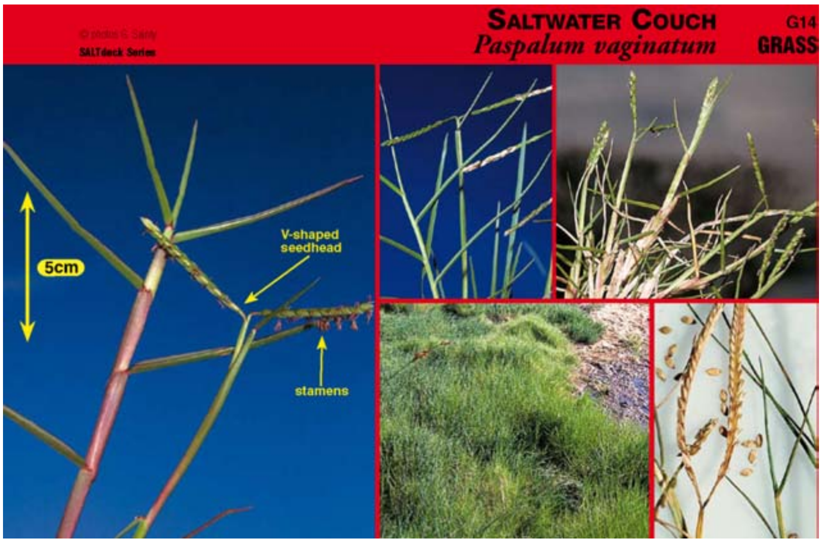
[*Refer to the Kingston Salinity Group SGSL tall wheat grass production trial, on the website www.landwaterwool.gov.au or contact the Struan PIRSA Office on (08) 8762 9100.]

Section 6.4 contains further information on establishment and management.

Salt water couch (Paspalum vaginatum)

Salt water couch has high waterlogging tolerance, some inundation tolerance and some ecotypes can tolerate salinity levels equivalent to seawater.

In Arabian Gulf States it is used as an ornamental grass and irrigated with seawater, after being established with fresher water. In South Australia it is suited to seepage areas that remain moist throughout the summer.



SALTdeck card series (Anon, 2006)

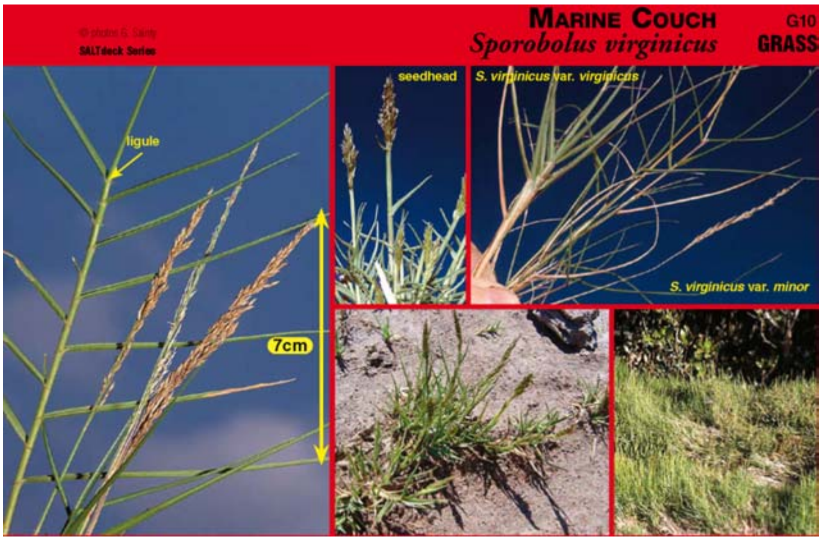
Salt water couch is a summer-growing perennial grass. It grows most rapidly with a combination of warm temperatures (> 25°C) and moist soils. It has high weed potential in moist environments including sandy beaches, wetlands and banks of waterways. It is not suited to drier sites.

The plant has a higher feed value than other grasses that grow in a similar environment. In a field experiment in northern Victoria, its digestibility ranged from 65-71%, and crude protein from 9.7-11.1% (pers. comm. Malcolm McCaskill, Vic DPI). As the plants grow on waterlogged sites, care will be required to prevent the sites being pugged. Dry matter production can vary between 1-7 tonnes/ha on saline land, and yields are influenced by the fertility of the site.

The plant is generally propagated vegetatively, by replanting established root matter.

Malcolm McCaskill at the Victorian Department of Primary Industries (Vic DPI) has been involved with trials of this species. Contact Vic DPI at Hamilton on (03) 5573 0900.

Marine couch (Sporobolus virginicus)



SALTdeck card series (Anon, 2006)

Marine couch is a highly regarded summer-growing halophytic perennial grass on seepage areas in NSW and Queensland.

It grows in similar areas to salt water couch (<u>seepage areas that remain moist throughout summer</u>), and has high waterlogging tolerance and moderate salinity tolerance. It tolerates pH values between 5 and 9. It tolerates dry conditions better than salt water couch. Plant roots can grow to at least 1.5m, and it is able to access shallow groundwater.

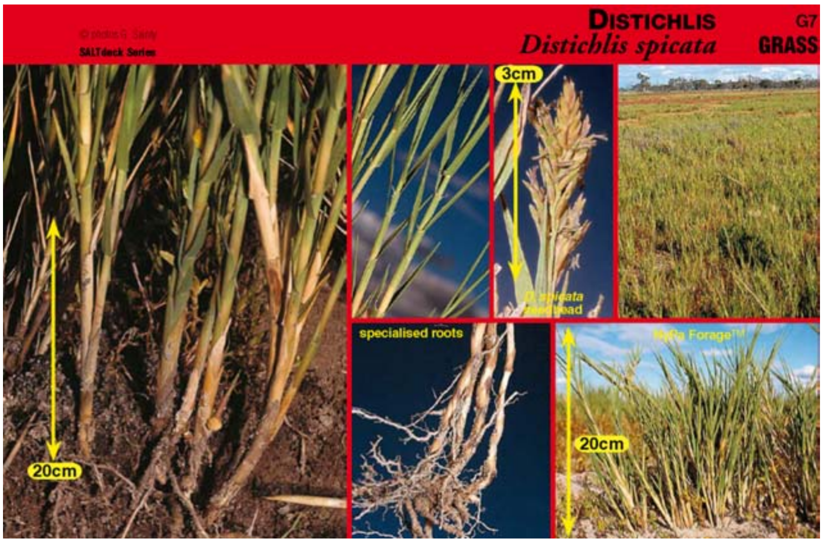
Plants vary in form from short prostate mats to tall and erect with fine-textured to coarse leaves. Despite its lack of bulk, it is reported to provide useful grazing, particularly the fine leafed forms.

It is palatable to sheep and has moderate feed value. In a field experiment (conducted through the SGSL program) in southern Victoria, its digestibility ranged from 54-63% and crude protein from 7.6-11.9%. This feed quality is sufficient for modest weight gains during summer, when sheep normally lose weight. Sheep grazing the pasture had weight gains averaging 45 g/day over summer at a stocking rate of 3.5 sheep per hectare (pers. comm. Malcolm McCaskill, Vic DPI).

It rarely sets seed and is therefore generally propagated vegetatively. Its stolons are able to grow across moist, scalded areas.

Malcolm McCaskill at the Victorian Department of Primary Industries (Vic DPI) has been involved with trials of this species. Contact Vic DPI at Hamilton on (03) 5573 0900.

Distichlis (Distichlis spicata)



SALTdeck card series (Anon, 2006)

Distichlis is another summer-growing grass that is highly tolerant to waterlogging, tolerant to inundation and highly tolerant of salinity (once established). In Australia it appears to occupy a similar niche to salt water couch and marine couch (requiring a warm climate and access to significant soil moisture). Crude protein values of 10% have been reported.

Establishment is difficult as it requires vegetative propagation via transplanting established root material. The plant is more susceptible to high salt concentrations during the establishment phase, but is capable of tolerating these conditions once established.

It is generally suited to warmer climates and is not likely to be suited to milder climates in southern South Australia. A consortium including NyPa Australia and Elders Ltd is trialling and marketing the plant in Australia.

LINK

Further information on distichlis (NyPa Forage™), including information from a trial site at Meningie in South Australia is available on the website: www.nypa.com.au .

The Victorian Department of Primary Industries is preparing an Agnote on NyPa Forage, which will be accessible through the website: www.dpi.vic.gov.au/notes .

5.5 SPECIES FOR HIGHER CAPABILITY SALTLAND

Many pasture legumes and grasses are relatively sensitive to salinity and waterlogging, however there is a niche for some of the more tolerant species in low to moderately saline land.

Their use can arise through one of the following scenarios:

- ***Low to moderate salinity levels***, ie. 'high capability saltland' where production levels can be optimised through the use of appropriate species.
- ***Seasonal reductions in salinity*** (eg. flushing of salts with the opening rains) which create a window of opportunity for sensitive annual species to thrive prior to the onset of salinity in mid to late spring (see Figure 12, Section 7.2).
- ***High water use halophytic species (eg. saltbush) are able to lower watertables*** thereby creating favourable conditions for more salt-sensitive but higher production shallow-rooted understorey species.
- ***Deep drainage*** has resulted in a lowering of groundwater levels. Areas that once supported only highly salt tolerant species, can now support more productive, less salt-tolerant species.

A range of pasture species in the low to moderate salt-tolerance range are shown in Figure 2 (Page 15) broadly grouped under the title 'species for higher capability saltland'. This figure illustrates this group's relative salinity and waterlogging tolerances in comparison to the major saltland pasture species. However it should be noted that varietal differences within species will cause variation in tolerance levels with adaptation to harsher conditions.

Caution!

For some species discussed in this section, information may be lacking on the performance and plant requirements under South Australian conditions. Plant information may have originated from interstate or other regions of SA (indicated where possible) and these plants may not perform exactly the same on your property.

For the more salt sensitive species growing in saline environments, the stress of salt may reduce the effective length of the growing season. Growers should consider that the stated minimum rainfall requirements (which are determined in non-saline conditions) may need to increase as salinity levels increase.

LINK

More information can be obtained on *species for higher capability saltland* (ie. low to moderate salt-tolerant legumes and grasses) through the following:

- See Figure 3 'Relative tolerance of crops and pastures to soil salinity' (page 17).
- Vic DPI Fact sheet – ***"Pastures for discharge areas"*** (Borg, 2005), available online at www.dpi.vic.gov.au/notes > Crops & pastures > Pastures (general) > Pastures for discharge areas [copy on CD-ROM].

- ***"Pasture plus: the complete guide to pastures,"*** published by the Kondinin Group (Casey, 1995).
- ***"Pasture legumes for temperate farming systems: the ute guide"*** (Wurst et al., 2004) [available from the Roseworthy Information Centre, Freecall: 1800 356 446, or online bookshop: www.ruralsolutions.sa.gov.au/bookshop].
- Refer to page 38 for sources of information on lucerne.
- PIRSA Fact sheet – ***"Permanent pasture mixtures for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island"*** (Fairbrother et al., 1999) [copy on CD-ROM].
- ***"Greener Pastures for South West Victoria"*** (Nie and Saul, 2006), including Chapter 10 'Managing pastures in saline areas' (McCaskill and Borg, 2006), Published by the Victorian Department of Primary Industries.
- Grassland Society of Southern Australia Inc. website: www.grasslands.org.au , which includes a pasture species database.
- ***"Saltland pastures in Australia: a practical guide"*** (Barrett-Lennard et al., 2003).
- A pastures information guide (available on the CD-ROM) prepared by Tim Prance, Senior Consultant Pastures & Grazing Systems, Rural Solutions SA. This guide contains information on pasture identification, growing seasons, preferences for rainfall, soils and pH, companion species and planting.
- Refer to the Yorke Peninsula Alkaline Soils Group (YP ASG) SGSL farmer trial in which a range of legumes (clovers, medics, lucerne, serradella, vetch and melilotus) where sown to determine their performance in varying salinity conditions. For details follow the SGSL links from the website: www.landwaterwool.gov.au, or contact the Yorke Peninsula Alkaline Soils Group (YP ASG) on (08) 8853 2241 (or web: www.alkalinesoils.com.au). These SGSL trial site summaries are also on the CD-ROM (#11a & 11b).

Selected key species are discussed in more detail below.

5.5.1 Legumes

Balansa clover (Trifolium michelianum)

Balansa clover is a widely recommended pasture/ understorey species for sites with a high risk of waterlogging.

It is a highly waterlogging tolerant pasture legume with low tolerance to salinity. Some varieties will persist in moderately saline environments due to their early flowering and avoidance of rising salinity levels later in the year.

SALTdeck card series (Anon, 2006)

The earlier flowering variety, 'Frontier', is relatively well suited to saline areas where salts are flushed by winter rains. Frontier can often mature and set seed before the onset of moderate salinity conditions. The trade-off of course, is lower production due to a shorter growing season. Frontier appears to be one of the best legume options where salinity levels are marginal for the maintenance of clover, for areas receiving around 450 mm rainfall or more per annum.

The original cultivar, 'Paradana', is a mid-season maturing variety and should only be grown in areas receiving more than 500 mm. 'Bolta' is a longer season variety and should only be sown where rainfall exceeds 600 mm per annum.

For persistence, stock need to be removed from the pastures at flowering during the establishment year. This first year is often critical in establishing a seed bank. Moderate grazing during flowering may be possible in subsequent years, provided pastures are achieving adequate seed set and regeneration. Dry residues must be grazed over summer to enable good regeneration. Balansa clover performs well over a wide pH range (4.2-8 in calcium chloride).

Lucerne (Medicago sativa)

Lucerne is one of the most valuable and widely grown perennial forages in the world and an integral component of recharge management for saline environments. Due to its deep tap root system it can utilise soil water at depth, reducing the leakage of water into groundwater systems.

Lucerne growing on slightly elevated ground in a mix with puccinellia and medics/ clovers (near Tintinara, Coorong Districts)

Lucerne is generally associated with recharge zones and low salinity environments, with the plant being widely used as an indicator species for sub-clinical, incipient or moderately low to moderate salinity impacts (particularly when combined with waterlogging).

While lucerne is generally not suited to groundwater discharge zones, due to its desirable high feed value various formal and informal breeding programs have yielded selections that have extended its range towards moderate salinity tolerance. Consequently lucerne can be a useful addition to pasture mixes in undulating saline landscapes. It will colonise where conditions are favourable on slightly higher, non-waterlogged ground. In the Coorong and Upper South East districts lucerne has been sown in mixtures on undulating saline ground with puccinellia, burr medic and clovers.

A significant disadvantage of lucerne is its inability to tolerate waterlogging, a common phenomenon in saline discharge zones or poorly draining areas (such as parts of the Upper South East). When the watertable rises, the taproot of lucerne can rot causing the plant to die off. The risk of waterlogging needs to be considered when sowing lucerne in saline landscapes.

Self-harvesting seed is practised by some producers to take advantage of the high productivity of the plant, while offsetting costs associated with a greater frequency of re-establishment. However the costs of seed harvesting and cleaning, as well as lost grazing, need to be weighed up against current prime lamb or cattle prices to determine the best option on economic grounds. While self-harvesting of seed may offer some genetic improvement in salinity tolerance, there may be questions over other aspects of plant performance in the following generations.

Other advantages such as increasing carrying capacity on non-wetting deep sands and stabilising soils susceptible to wind and water erosion make it an excellent pasture choice.

When selecting lucerne varieties it is important to choose those that best suit your enterprise and conditions. Lucerne varieties show a range of seasonal activity, with dormancy scales between 1 (winter dormant) and 10 (very highly winter active). Of the commercially available varieties, SARDI Seven and SARDI Ten have improved persistence in marginal environments in South Australia.

SARDI Seven is the best long-term option for lucerne under marginal salinity and waterlogging stress. SARDI Ten will deliver more winter production (and therefore higher total annual yield) at the expense of long-term persistence. This variety is more suited for phases of lucerne of 3-5 years in rotation with crops.

Trial results from a highly saline flat near Tintinara (T. Egel's property) show that local breeding efforts to improve persistence in wet, salty environments have been successful. Figure 6 (below) shows results for persistence of winter active cultivars SARDI Seven, Eureka, UQL-1, Aurora, Hunterfield and Trifecta, and highly winter active lucernes SARDI Ten, Sceptre, Rippa, WL525, PL90 and Salado.

For lucerne, the establishment phase is very important, and can often dictate the success of the stand. Lucerne is generally suited to areas with greater than 350 mm rainfall. As rainfall approaches this lower limit, establishment is likely to be more difficult and the plant density in established stands will be diminished.

LINK

More information on lucerne can be found through the following resources:

- ***"Success with lucerne"*** (Stanley et al., 2002). This manual can be viewed or purchased at any PIRSA Office.
- ***"Lucerne prospects: drivers for widespread adoption of lucerne for profit and salinity management"*** (Robertson, 2006)**,** published by the CRC Salinity.
- ***"Making lucerne pay: integrating crops and lucerne on mixed farms"*** (Vic DPI, 2006), Available through Vic DPI Bendigo, phone: 03 5430 4451 or online at www.grdc.com.au/bookshop/sale.htm .

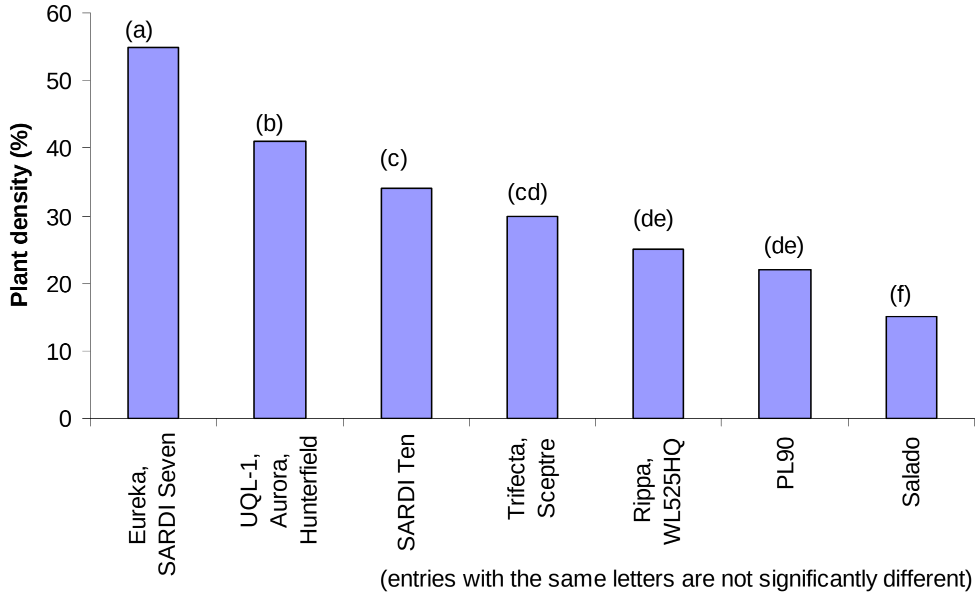
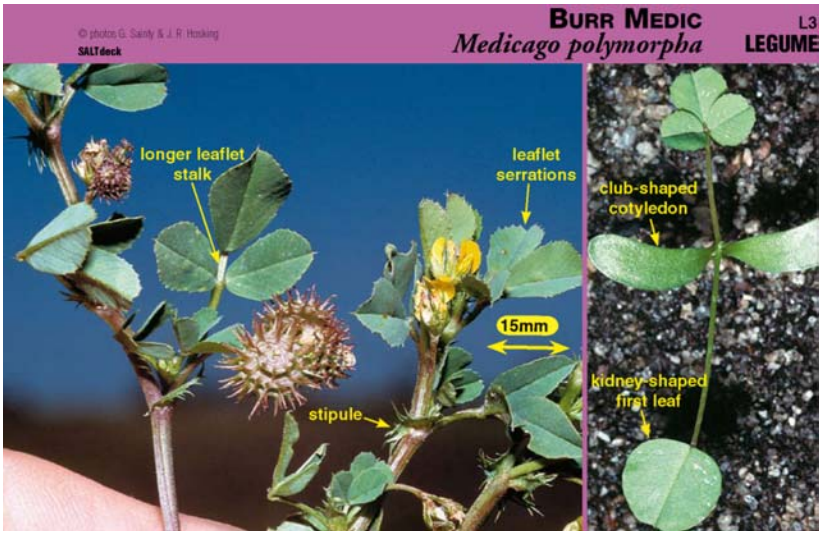


Figure 6. Plant Density of lucerne varieties on 5 year old lucerne at Tintinara, April 2006 (pers. comm. Alan Humphries, SARDI senior lucerne breeder).

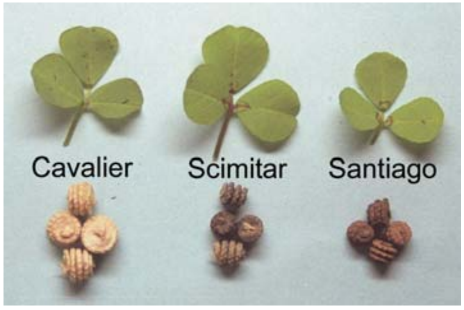
Burr medic (Medicago polymorpha)



SALTdeck card series (Anon, 2006)

Burr medic is an often recommended pasture / understorey species for sites with low to moderate salinity and transient waterlogging.

Early flowering varieties are more likely to avoid the onset of salinity, in what would otherwise be classed as moderately saline environments. These plants grow during winter periods following the winter flush.



Wurst et al., 2004

Spineless burr medics

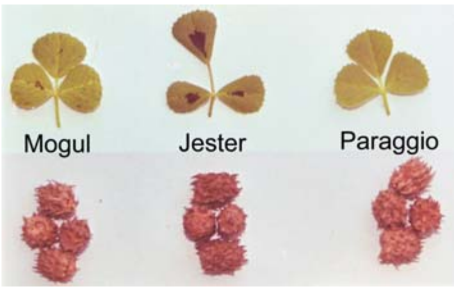
From experience in the Upper South East, Eyre Peninsula and Western Australia, the commercial spineless varieties 'Santiago' (early season maturing, > 325 mm), 'Scimitar' (early to mid-season maturing, > 350 mm) and 'Cavalier' (early to mid-season, > 375 mm) appear tolerant of low to moderate salinity levels and transient waterlogging (up to around 2 weeks). As salinity levels increase, minimum rainfall requirements may be higher. South East trials have shown Scimitar to be the best performed variety due to its lower level of hard seed, leading to more reliable regeneration.

On Eyre Peninsula, burr medics have persisted in moderately saline environments, where they have been seasonally present as a volunteer companion species to puccinellia.

On Kangaroo Island, burr medic sown in the mid 1950s is now a viable pasture component in moderately saline environments (with seasonal salinity reductions), thanks to modern fertilisers.

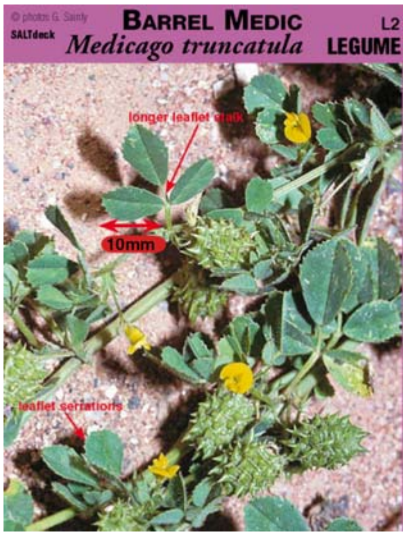
Barrel medic (Medicago truncatula)

Barrel medic is suited to sites with a low waterlogging risk and, like burr medic, is an understorey species for low to moderately saline environments which are flushed by winter rains.



Wurst et al., 2004

Barrel medics

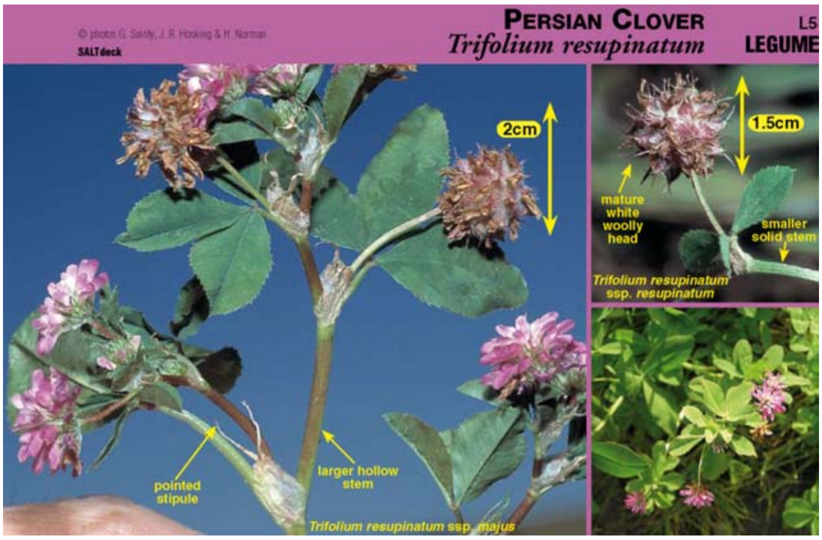


SALTdeck card series (Anon, 2006)

Barrel medic produces many hard seeds that can improve persistence during a drought phase.

On coastal creek flats near Tumby Bay (Eyre Peninsula) that experience seasonal moderate salinity and only low waterlogging risk, the variety 'Jester' has performed well in areas where previously balansa clover had failed. Monitoring is ongoing at this site to determine levels of regeneration and persistence. Jester is a mid-season maturing variety adapted to > 350 mm rainfall regions throughout the southern wheat belt.

Persian clover (Trifolium resupinatum)



SALTdeck card series (Anon, 2006)

Persian clovers have high waterlogging tolerance but low salinity tolerance. They have shown excellent tolerance of high pH's (eg. in the Upper South East, where they have been used successfully in the Woolumbool sand over clay systems). Varieties include 'Kyambro' (> 600 mm) and 'Prolific' (> 450 mm). The varieties 'Res B', 'Lightning' and 'Morbulk' have persisted in moderately low to moderate salinity environments in trials conducted by the Yorke Peninsula Alkaline Soils Group. Early flowering varieties 'Nitro' and 'Prolific' are recommended to avoid the onset of salinity later in the season, in areas receiving 450 mm or more annual rainfall.

Strawberry clover (Trifolium fragiferum)

SALTdeck card series (Anon, 2006)

The perennial strawberry clover (cv Palestine) has moderate salinity tolerance. It is suited to higher rainfall areas (> 525 mm) or areas that continue to have available soil moisture through the late spring to summer period via access to a watertable. Access to this soil moisture is essential due to its summer growth period. Strawberry clover is unlikely to persist in some areas (< 500 mm annual rainfall) without additional moisture from the local watertable.

5.5.2 Grasses

Tall fescue (Festuca arundinacea)

Tall fescue is a deep-rooted perennial grass that is tolerant of low to moderate salinity and moderate waterlogging. Tall fescue needs a “floor” or a base, (ie. it doesn’t like deep sands) unless the soil is moist. It prefers rainfall over 600 mm. However some summer-active varieties may be suitable for areas with over 500 mm and new winter-active varieties may cope with even drier climates.

Nie & Saul, 2006

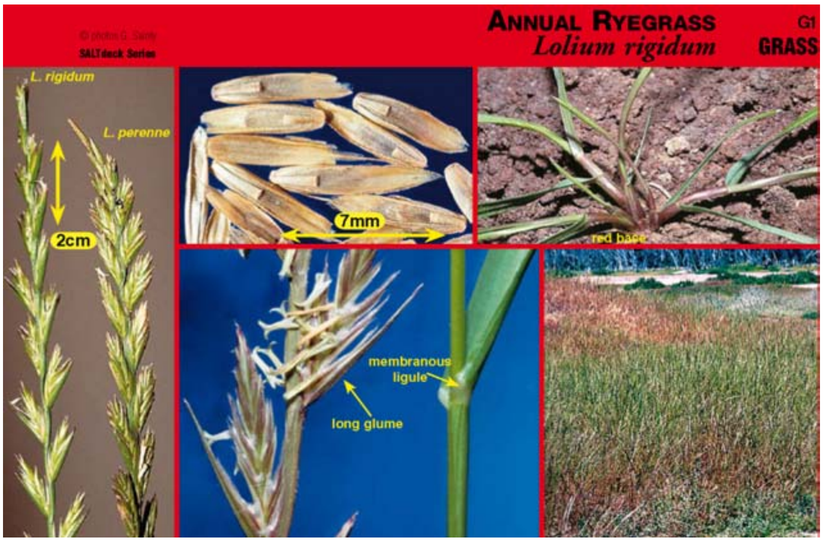
Tall fescue

With good management (and suitable rainfall) it can be very persistent, remaining green over the summer, and also combines well with legumes. The variety ‘Demeter’ is summer growing and is said to be the most tolerant to saline, poorly drained areas. The new winter active fescues can be established in lower rainfall areas (> 400 mm) however persistence has not yet been proven; observations in the Upper South East show ‘Resolute’ and ‘Fraydo’ the better varieties. Poor seedling vigour may be an issue, making weed control critical to successful establishment.

Victorian trials have shown the varieties Resolute and Advance will germinate and grow at ECe levels up to approximately 8 dS/m, losing up to 50% of productivity at this salinity level (pers. comm. Dion Borg, Vic DPI).

Annual ryegrass (Lolium rigidum)

Annual ryegrass has moderate salinity tolerance and is more suited to heavier soil types. To get high water use in the system, strawberry clover can be established with it in areas influenced by the watertable. Ryegrass can have negative allelopathic effects on other germinating grass seeds. That is, ryegrass releases chemicals into the soil which reduce the germination and competitiveness of some other grasses. In the case of silver grass this is a good thing. However because of these allelopathic effects, it is not recommended to be sown with species such as phalaris. If in doubt, advice should be sought. Also puccinellia should not be sown where annual ryegrass dominates as it will have trouble persisting.

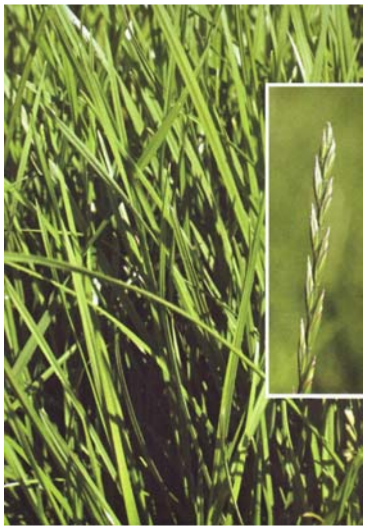


SALTdeck card series (Anon, 2006)

Perennial ryegrass (Lolium perenne)

Perennial ryegrass has high feed value and is easily established but prefers the higher rainfall areas (> 600-650 mm), with heavier and higher fertility soils. Salinity tolerance is variable across the large range of cultivars. 'Victorian' is the main cultivar sown as it has better drought tolerance and is more persistent in the marginal areas for perennial ryegrass than most other cultivars.

Perennial ryegrass has strong allelopathic properties and should never be sown with other perennial grasses.



Nie & Saul, 2006

Perennial ryegrass

Phalaris (Phalaris aquatica)

Phalaris has low to moderately low salinity tolerance (< 6 dS/m) and good waterlogging tolerance, though requires excellent weed control for good establishment. It prefers rainfall over 425 mm. Newer varieties such as 'Atlas' and 'Holdfast' are able to be established in areas with greater than 400 mm. For persistence at the low rainfall end of their range, they prefer sand over clay soil types and are considered highly suitable for post-drainage areas that may still be subjected to a certain level of waterlogging and/or low salinity levels.

Nie & Saul, 2006

Phalaris

Kikuyu (Pennisetum clandestinum)

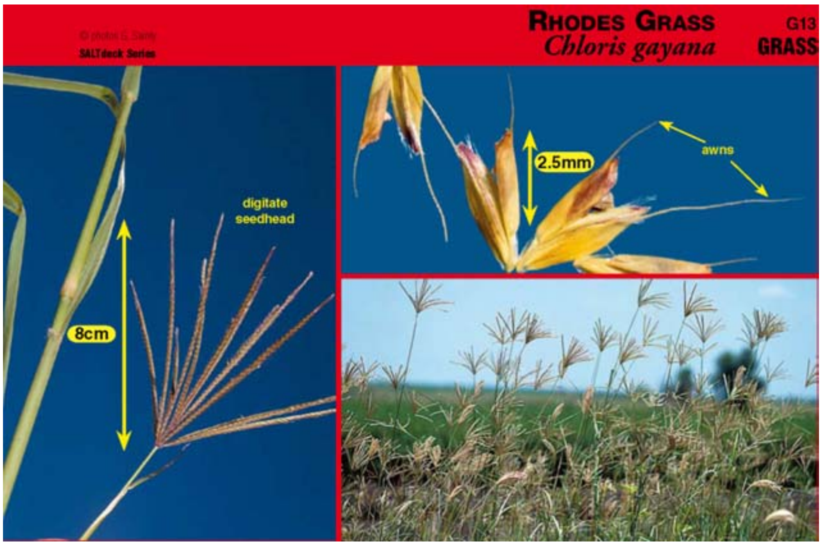
Kikuyu has an excellent capacity to use moisture at depths down to 60 cm in the soil profile and generally has low to moderate salinity tolerance and moderate waterlogging tolerance. It is generally suited to deep sands.

It is likely to be suited to seepage areas of low to moderate salinity. However due to it's high escape weed potential, care should be taken. It's use should be avoided adjacent to wetland or biodiversity areas.

SALTdeck card series (Anon, 2006)

Cultivars 'Whittet' and 'Noonan' have grown successfully on higher salinity scalds (Barrett-Lennard et al., 2003).

Rhodes grass (Chloris gayana)



SALTdeck card series (Anon, 2006)

Rhodes grass is a sub-tropical tufted perennial grass, growing to a height of about 1.5 m. Field trials in NSW and Queensland suggest this plant may be of value on mildly saline seepages.

It has low to moderate salinity tolerance and moderate waterlogging tolerance.

Information from Western Australian trials suggests this plant does not tolerate frost and has similar salinity tolerance to lucerne.

On Kangaroo Island, Rhodes grass has been trialled on moderately saline sites (including raised beds) in rainfall zones of 450 mm and greater. The plant has performed well where it receives good summer rains.

5.6 MIXED SALTLAND PASTURES

> Where salinity & waterlogging vary across a paddock, a "shotgun mix" of different pasture species can often work well.

In some saline landscapes, undulations of only a few centimetres can determine the success of pasture establishment of different species. Seasonal differences in rainfall and watertable height can add to the variability in conditions impacting on pasture species.

In this type of undulating saltland, where soil and salinity conditions vary across a paddock, production is often maximised by sowing a mix of pasture species.

Sowing a mix provides a means for producers to 'hedge their bets' in areas they are unsure about. Some species will persist while others will fail. However if salinity levels are high, highly salt-tolerant puccinellia is likely to be one of the few productive species that will survive.

It should be noted that shotgun mixes can potentially cause difficulties in grazing management, in contrast to single pasture (and legume) systems which are easier to manage and often preferable where possible. In some cases, pastures such as puccinellia, tall wheat grass and even lucerne might need to be managed together. It is not always practical to fence off the different areas.

Mixed pastures should be rotationally grazed to maintain the persistence of the most susceptible / palatable species. This is often lucerne (where present), or puccinellia. This grazing regime may mean that tall wheat grass (where present) will become rank. Cattle will graze tall wheat grass better than sheep if it gets into this state. Alternatively tall wheat grass can be slashed to improve quality.

Further information on seeding rates for pasture mixes is shown in Section 6.6 'Establishment & Management – pasture mixes.'

A useful resource for looking into companion species (and a range of other pastures information) for some low to moderately salt tolerant species is the pastures information guide available on the CD-ROM. This was prepared by Tim Prance, Senior Consultant Pastures & Grazing Systems, Rural Solutions SA.

High rainfall pasture mixes

Information on a range of pasture mixes suited to high rainfall areas can be obtained from the PIRSA Fact Sheet ***"Permanent pasture mixtures for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island"*** (Fairbrother et al., 1999), available through PIRSA Offices (or copy on the CD-ROM). Similar to the previously mentioned information guide, this fact sheet does not discuss 'saltland' as such, but does discuss some low to moderately salt tolerant pasture species.

Post drainage environments

Mixed pastures sown into original saline paddocks that have been drained have shown that, whilst not all species germinated in the initial year of sowing, they appear in the following seasons as the watertable drops and the salt is leached from the soil post drain construction. This may also be a function of other rapid changes in the drained soils (eg. drop in pH, chemical changes).

Crops on saline land

Growing crops may be an option on moderately saline land. This may arise through:

- a phase farming operation (where crops are grown for a number of years, in rotation with a perennial pasture for a number of years);
- crop species grown for grazing; and/ or
- crop/ pasture/ legume mixes for hay production.

Crops such as barley and canola are moderately salt tolerant, however low waterlogging tolerances may pose a large risk with these species. Table 6 shows some examples of crop species and their salinity tolerances.

Currently research is focussing on the development of salt-tolerant wheat using some of the genes from the weed sea barley grass, however this would not be expected to be commercially available for several years.

Table 6. Examples of crops and their tolerance to salinity

Crop species	Soil salinity at which significant production losses occur ECe (dS/m)
Peas	3.0
Lupins	3.0
Faba beans	3.0
Vetch	4.0
Oaten hay	4.2
Oats	5.5
Lucerne	3.5
Barley hay	7.4
Wheat	7.4
Triticale	7.8
Cereal rye	8
Canola	8.4
Barley	10

6 ESTABLISHMENT & MANAGEMENT

Hopefully by this stage, suitable saltland pasture species for your site have been identified (as per the 'step by step approach', Section 3.1).

This section contains general principles for establishment and management followed by specific information for the major saltland pasture systems in South Australia, which comprise:

- Saltbush based pastures,
- Puccinellia based pastures,
- Tall wheat grass based pastures,
- Species for higher capability (less salty) saltland, and
- Pasture mixes for undulating/ variable saltland.

6.1 GENERAL PRINCIPLES

Summary points:

- For establishment:
  - Plan.
  - Consider native vegetation issues (where applicable).
  - Prepare the site (consider drainage, fencing and water).
  - Control weeds and pests.
  - Apply fertiliser (where appropriate).
  - Cultivate and seed, according to plant requirements.
  - Delay onset of grazing to allow proper establishment.
- For ongoing management:
  - Control grazing (according to priorities – shade soil in summer, persistence, out of season feed, water use and/or to control feed quality).
  - Feed supplementation (consider energy and protein levels).
  - Fertiliser (N and P, rates and timing, when to and when not to fertilise).
  - Control weeds.
  - Ensure adequate supplies of good quality water for stock.

6.1.1 Planning

A well planned strategy for establishing saltland pasture systems is required to minimise costs and give the best results. The following principles are recommended:

- Development should occur in stages, and as finances and soil/ hydrogeological (groundwater) conditions permit.
- Give the highest priority to higher capability areas. These are the easiest to approach, offer good prospects for success, and provide the most potential return on investment.
- Consider the establishment and management principles mentioned below.

6.1.2 Native vegetation and saltland development

Areas of primary salinity (characterised by naturally very highly to extremely saline land) are important for biodiversity and should be left in their natural state. Often they comprise areas of swamp or wetland that can support a range of fauna species (including migrating waterbirds if they undergo periodic flooding). As a first step, primary salinity areas should be fenced off. Fringe (or buffer) plantings of local native species will provide additional environmental benefits.

Native vegetation, including samphire, is protected under the *Native Vegetation Act 1991*. However, on land that has become affected by dryland salinity (secondary / human-induced salinity), the regulations under The Native Vegetation Act do provide for the clearance of samphire for saltland pasture management subject to a management plan being approved by the Native Vegetation Council (see further details below).

Important!

Important notes for native vegetation

Any native vegetation is protected through the *Native Vegetation Act 1991* ('The Act') and its associated regulations and amendments.

Native vegetation on saltland (eg. samphire, *Melaleuca halmaturorum* [KI Paperbark], etc.) will be damaged or killed by:

- Clearance or cultivation;
- Grazing or changes to grazing management; or
- Changes to the flow of water across and/or beneath the landscape (eg. greatly improved drainage, or pooling of drainage disposal water). Degradation or death of plants caused by drainage is also viewed as 'clearance'.

The Act stipulates that:

- ***On non-farming land***, approval for native vegetation clearance should be sought from the Native Vegetation Council.
- ***On land that has been used for agricultural purposes but has become degraded*** through a regional land degradation process over a period of time (eg. secondary salinisation / dryland salinity), thereby allowing native vegetation such as samphire to colonise the land – that clearance may be undertaken [Regulation 5(1)(zfb)], provided all three of the following conditions are met:
    - the vegetation to be cleared must be on land that is being used, or has previously been used, for agricultural purposes; and,
    - the clearance is being undertaken to enable the land to be used for agricultural purposes; and
    - the clearance is undertaken in accordance with a management plan that has been approved by the Council.

It should be noted that areas of very high to extreme (primary or secondary) salinity have low capability (productive potential) and are not recommended for saltland pasture establishment. Economic returns from developing this type of country are at best marginal.

Table 7 provides a summary of a range of situations, along with the conditions required to be met, where approval for the clearance of native vegetation may be granted under The Act (Native Vegetation Council Secretariat, 2006).

Table 7. Relevant situations where approval may be granted for native vegetation clearance for saltland pastures on farming land. See Native Vegetation Council Secretariat (2006) for further details.

	Situations			
Conditions	**Clearance of regrowth to maintain pasture ('5 year rule')** Regulation 5(1)(zf)	**Clearance of regrowth greater than 5 years old** Regulation 5(1)(zfa)	**Clearance of degraded land (eg. on secondary saline sites)** Regulation 5(1)(zfb)	**Clearance by grazing (eg. grazing samphire on primary salinity sites)** Regulation 5(1)(zh)
The land on which the vegetation is situated has been used for agricultural purposes…	✓ (within the preceding 5 years)	✓ (consistently since the land was lawfully cleared)	✓ (although use has been reduced due to degradation)	
The clearance is necessary so that the land can continue to be used for agricultural purposes…	✓ (to the extent of use in the preceding 5 years)	✓	✓	
Vegetation to be cleared consists of regrowth…	✓ (from the preceding 5 years)	✓ (over a period of time after the previous lawful clearance)		
The land has been the subject of a regional land degradation process over a period of time (eg. dryland / secondary salinity), and the vegetation to be cleared has grown due to those processes.			✓ (eg. samphire colonising a secondary saline site)	
Provided conditions are met, clearance is permitted without application.	✓			✓ (by grazing - if the stock type, manner & rate of grazing are consistent with the previous 10 years)
Clearance should be undertaken in accordance with a management plan approved by the Native Vegetation Council.		✓	✓	✓ (if there are proposed changes to the stock type, manner or rate of grazing)

Further information relating to native vegetation clearance is available through the following websites:

- Clearance application package and related information, at: www.dwlbc.sa.gov.au/native/nvsa/application.html .
- Clearance controls and example regrowth management plan, at: www.nvc.sa.gov.au/native/regrowth/index.html .
- Link to updated Native Vegetation Regulations, at: www.nvc.sa.gov.au/native/nvsa/clear.html#WhereNativeVegetationCannotBeCleared .

  A copy of the document ***"A Guide to the Regulations under the Native Vegetation Act 1991"*** (Native Vegetation Council Secretariat, 2006) is on the CD-ROM.

6.1.3 Site Preparation

Mitigation works

A range of site improvements may be possible to alleviate conditions of salinity, waterlogging or other soil limitations, thereby increasing the options for production.

Mitigation works have the potential to dramatically improve saltland. For example, at Ungarra on Eyre Peninsula, improved surface and groundwater drainage (through clearing silted up creek lines), and the establishment of high water use saltbush, along with some drier years, has allowed more productive understorey species to grow. From invading samphire in 2001, this site now supports an old man saltbush stand with inter-row pastures dominated by ryegrass and medics (Figure 7). Stocking rates have improved from less than 1 DSE/ha to 5-8 DSE/ha.

2001 – Invading samphire plants in this salinised paddock indicate the high levels of salinity at the time of saltbush establishment.

Dec 2005 – Following improved drainage, and establishment of deep-rooted saltbush, ryegrass and medics now dominate the inter-row pastures.

Figure 7. Salinity mitigation measures can improve site conditions, allowing more productive species to grow (Ungarra, Eyre Peninsula).

Surface water management

Saline areas are typically low-lying and often subject to flooding (inundation) following periods of heavy rainfall. This can produce significant recharge, causing shallow watertables for considerable periods following the episodic flood/ recharge events.

Where sites suffer from severe waterlogging or surface inundation, drainage should be considered before any other development work is carried out. [As an alternative, periods of drought can provide an opportune time to establish pastures on ground that is usually waterlogged.]

It is also worth considering that species such as puccinellia are reported to benefit from winter-spring flooding, provided that floodwaters do not stagnate (page 30). In this case, some surface water drainage may still be required to keep the surface water moving.

Consideration should be given to the disposal of the drainage water, and impacts to downstream biodiversity and landholders, prior to drain construction (see ***Important notes***, below). Guidance can be sought from your regional NRM Board or DWLBC. In the Upper South East, licences must be granted by the South Eastern Water Conservation and Drainage Board (SEWCDB) prior to drainage being undertaken. [Also refer to the SEWCDB drainage fact sheet, described below.]

Where possible, shallow surface water drains and levee banks can be used to aid in the dispersal of surface water flows. Observe where water flows during the previous winter to determine flow patterns. Survey and install W-drains or other drains, interceptor/ diversion banks as appropriate.

Where drainage is not feasible consideration should be given to least affected areas first.

Groundwater drainage

Groundwater drains can help to lower watertables. The time for positive impacts to be seen will depend on groundwater level gradients and soil types. Due to their poor permeability, clayey soils are generally not recommended for constructing groundwater drains.

As for surface water drainage, disposal of water, impacts to downstream biodiversity and landholders, and any impacts that construction of the drain may have on native vegetation, need to be considered prior to drain construction (see ***Important notes***, below). Guidance can be sought from your regional NRM Board or DWLBC. In many areas drainage requires permits to be granted (eg. in the Upper South East, application is made to the South Eastern Water Conservation & Drainage Board).

Important!

Important notes on surface and groundwater drainage

- ***Impacts to native vegetation:***

  As previously discussed, drainage can damage or kill protected native plants. Impacts on native vegetation need to be considered (see page 46).

- ***Impacts to other landholders:***

  Landholders have a duty of care not to harm others. Farmers need to ensure that disposal of surface and/or groundwater does not simply shift the problem to someone downstream. Downstream landholders need to be adequately consulted. Where permits are required there needs to be signed agreement with neighbours before drainage can occur.

- ***Impacts to watercourses:***

  Disposal of water should not degrade downstream aquatic ecosystems. Seek guidance from local council, Regional NRM Boards or DWLBC.

- ***Design:***

  Professional advice should be sought regarding drainage design. Batters should be designed according to soil type for stability and they should be able to cope with large rainfall events.

For further information on constructing drains refer to the following:

- South Eastern Water Conservation and Drainage Board fact sheet: ***"Private drainage in the Upper South East"*** (in preparation). Contact the SEWCDB on (08) 8733 3533.
- Upper South East Dryland Salinity and Flood Management Program fact sheet: ***"Drainage: reducing flooding and salinity."*** See copy on CD-ROM, or the website: www.dwlbc.sa.gov.au/land/programs/use/factsheets.html#Drainage

- NDSP fact sheets on surface and groundwater drains (eg. mole, tile, interceptor, reverse interceptor, W-drains, Wisalts banks, deep drains) [copies on CD-ROM].
- DWLBC Fact Sheet #15 – ***“Engineering options for salinity management”***, available from website: www.dwlbc.sa.gov.au/publications/fs_brochures.html [copy on CD-ROM].

LINK

Permit applications for water-affecting activities and drainage or discharge to watercourses or lakes are found on the DWLBC website: www.dwlbc.sa.gov.au/licensing/information/permits/index.html .

High plant water use

Additional options to mitigate salinity impacts, through higher plant water use, include:

- Planting lucerne, tagasaste or other high water use plants on high recharge potential areas (eg. sand dunes) adjacent to saline discharge areas.
- Planting saltbush to lower watertables on saline sites.
- Revegetation of significant areas with local native species.

Mounding / raised beds

Forming raised soil beds (see Figure 8) is another way to alleviate salinity and waterlogging. Small scale differences in elevation provide high zones enabling salts to be leached and drainage channels for salts to be flushed away from the paddock.

However potential drawbacks of raised beds are difficulties for stock movement and maintaining the form of the soil beds.

Other technical issues have been highlighted in SGSL trial work (conducted by the KI NRM Board):

- Unevenness in bed formation can make it difficult to achieve the correct seeding depth, which may result in poor or patchy pasture establishment.
- Bed formation can bring saline soil from depth to the surface. This may mean a greater delay between bed formation and seeding is required to enable rainfall to leach out salts.

Figure 8. Raised beds on Kangaroo Island (left) and raised bed former (right).

Other Soil limitations

Other soil limitations may impede plant productivity and hence water use (thereby exacerbating salinity) or result in unfavourable conditions for certain species. Conversely, where these issues can be addressed this may improve plant water use or open up new opportunities for more productive pasture species. Soil testing and agronomic advice can indicate the cost-effectiveness of potential management actions.

Examples include:

- ***Fertility:*** specific fertiliser requirements for a range of species are discussed later.
- ***Acidity:*** the application of lime will help to increase soil pH to more favourable levels.
- ***Sodicity:*** gypsum can help alleviate poor soil structure associated with sodicity. When flushed of salt (eg. following rains), sodic soils (surface and/ or subsoil) may become dispersive when wet and hard-setting when dry.

Fencing

Where possible salt-affected areas should be fenced off to control grazing and assist with pasture establishment. Fence well outside salt-affected areas (taking account of the rate of expansion of salinity) and make fences as straight as possible. Temporary or electric fencing offers some cost saving, and may also be of use in setting up more intensive rotational grazing systems, particularly as an initial trial-and-error period may be required to establish optimum cell sizes.

Fencing to land class (separating saline and non-saline land) is preferable. This is of benefit not only for salinity and grazing management but also a range of land management issues.

Where fencing is not feasible for smaller or irregular areas, adjacent (non-saline) land could be cropped for two years during pasture establishment.

Water points

Stock grazing on saline pastures require access to good quality drinking water. The quantity and location of water points will depend on the grazing management approach to be adopted (eg. set stocking or rotational grazing).

6.1.4 Weed and insect control

Weeds

Weeds in saltland pastures are discussed in Section 10 (page 105).

Insects

Red legged earth mite (RLEM), in particular, should be monitored and controlled during the establishment phase. Ongoing management will be required in pastures including lucerne and clovers. The Timerite® program (see website: www.timerite.com.au) is an excellent tool for managing RLEM.

Caution!

Care is required with RLEM control adjacent to wetlands as this can pose a threat to microfauna health, particularly when aerially applied.

Other pests can include aphids, lucerne flea and native budworm.

6.1.5 Fertiliser

The use of fertiliser on saltland should be flexible and opportunistic. Farmers need to recognise the limitations of their particular country and the seasonal conditions. However fertiliser applications can help to optimise production when conditions are right.

Appropriate fertiliser regimes will vary depending on the particular pasture species and a range of other factors. For instance, saltbush generally only requires fertiliser during establishment, while pasture grasses such as puccinellia and tall wheat grass can significantly benefit from ongoing fertiliser applications. Economics will be the main factor in determining whether or not it is appropriate to apply fertiliser. Timing of application is another factor.

Timing of fertiliser application can be important, for example:

- When applying fertiliser in accordance with the active growth phase of certain species.
- If trying to maximise different aspects of production (eg. green feed, hay cuts, seed for harvesting).
- Considering the influence of soil temperatures on plant growth (eg. nitrogen inputs may be largely wasted if low soil temperatures restrict growth in winter). Greater production levels can be achieved if pastures are fertilised when soil temperatures are higher.
- In respect of rainfall, allowing for adequate moisture, but avoiding wasted fertiliser inputs if excess rainfalls and waterlogging are likely. Adequate soil moisture is also important for minimising volatilisation losses in urea.

Ongoing fertiliser applications may be unnecessary once critical threshold levels have been reached. For example, in puccinellia-dominant pastures at the SGSL research site at Mt Charles in SA, annual applications of superphosphate resulted in no additional pasture growth benefits due to the strong history of phosphorus fertiliser application and high base levels of soil P (25 mg/kg Colwell P). It is generally considered that additional phosphorus fertiliser is not necessary once levels of soil P equal or exceed 12 mg/kg (Colwell P).

Where clovers are growing (during winter periods of reduced salinity), these species will determine P requirements rather than the more salt-tolerant species.

Nitrogen fertiliser applications will generally not be required where pasture species are already benefiting from nitrogen released into the soil by clovers or other leguminous pasture species. Of course, the presence of these advantageous species in the pasture mix often relies on favourable soil conditions, including relatively low salinity levels.

It may not be economically worthwhile to apply fertiliser in the following situations (because other factors apart from fertility are likely to be limiting pasture productivity):

- Shallow soils (where productivity is limited by soil depth, through physical or chemical barriers).
- Very highly to extremely saline and/or waterlogged soils.
- Hostile soils due to pH, boron, etc.
- Where pastures are expected to have a short life expectancy (eg. due to recurrent waterlogging and inundation – refer to Section 13 and the case study of Trevor Egel's property).
- Where legumes (clovers, medics) already provide nitrogen inputs to the pasture.

Further discussion of the economics of fertiliser applications is contained in Section 12.2 'Tools for estimating profitability – pasture response to fertiliser calculator'.

6.1.6 Cultivation and seeding

Saline areas generally benefit from cultivation (roughening up) prior to seeding, so that rainfall can leach salts out, and a range of micro-topography (and salinity levels) will provide at least some suitable ground for seed germination. This is particularly the case for more clayey soils. Finer seeds, such as puccinellia, often require more cultivation to ensure a fine tilth or seed bed.

Generally speaking, the more saline the ground is, the rougher (more highly ridged) it should be, and rolling will not be recommended.

Sandier soils will allow more leaching of salts, and can often benefit from a light rolling to improve moisture retention and seed contact with the soil.

However decisions on rolling to improve seed contact or moisture retention should be based on the particular country and also seasonal conditions, such as the likelihood of waterlogging that year. Local advice should be sought.

Caution!

It is important to obtain certified seed or conduct germination tests, particularly if the seed is coming from an unfamiliar source or has been stored for more than 1 year. Failed establishment due to bad seed is expensive, and may destroy motivation for future efforts.

6.1.7 Grazing management

Discipline is required in annual grazing management so that adequate cover is retained over the heat of the summer, in order to minimise the build up of soil salinity. This also ensures the maximum feed available for the autumn feed gap that saltland agronomy offers.

Where possible, fencing to land type (allowing saline and non-saline areas) to be managed separately is recommended.

Different pasture species will then have different requirements for grazing, based on factors such as seasonal growth patterns, feed quality and susceptibility to over-grazing.

6.2 SALTBUSH BASED PASTURES

Background information

Saltbush can be direct seeded or planted as nursery grown seedlings (or bare-rooted 'speedlings').

Saltbush is suited to better drained sites with average annual rainfall between 300-450mm and moderately low to high salinities. Very high to extreme salinity sites will not be suitable due to low production and questionable profitability, and are usually best managed for environmental/ biodiversity values.

The feed value of saltbush is generally low to moderate, however production will be maximised if understorey pastures (clovers/ medics or salt-tolerant grasses) can also be established.

Further background information on a range of saltbush species is contained in Section 5.3.

Acknowledgement: a major source of information for this section on saltbush establishment and management has been Barrett-Lennard and Phelan (in prep).

6.2.1 Designing your saltbush system

Layout

Generally speaking, saltbush can either be grown as:

- ***Dense stands.***

  This layout is appropriate on more saline sites (moderately high to high salinity).

  Saltbush is planted at close spacings because more productive, salt-sensitive understorey species will not persist on this ground.

  Occasional 10m wide tracks should be included for vehicle access (eg. fertilising and fire-fighting), with enough room for a truck to turn around at the end of the row.

  Cautionary note: if saltbush is planted in closely spaced rows this doesn't allow further inter-row pasture improvement at a later date, once saltbush has lowered the watertable and soil conditions under the stand have improved. If soil conditions are expected to improve (following high water use by the saltbush) larger inter-row spacings (as described below) should be considered at the outset.

- ***Rows (alleys) of saltbush with an understorey of annual legumes and/or perennial grasses.***

  This layout is appropriate on less saline sites (moderately low to moderate salinity).

  Understorey species are more salt-sensitive and have higher production, hence the requirement for higher capability saltland.

  Spacings between saltbush rows will need to be wide enough to take your planting gear (drill or air seeder), to enable sowing of the understorey.

Layouts can be customised to suit particular situations, however Table 8 provides a guide to potential layouts.

Native vegetation

Remember that native vegetation (including samphire) is protected. Important considerations when looking to establish saltland pastures are discussed in Section 6.1.2 (page 46).

Table 8. Guide to designing your saltbush stand.

Salinity level	Moderately Low		High	Very high to extreme
Example layout	Alleyed stand Double rows of saltbush with 20m understorey bays. xx xx xx xx xx xx xx xx xx xx	Alleyed stand Double rows of saltbush with 12m understorey bays. xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx	Dense stand Multiple closely spaced rows, with 5m inter-row spacing. xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx	Not suited to saltbush establishment. Fence and protect from grazing. Allow natural regeneration/ revegetation.
Planting density	500-1000 stems/ha	< 1500 stems/ha	> 2000 stems/ha	
Access consider-ations	Wide enough for seeder. Room to turn around at end of rows.	Wide enough for seeder. Room to turn around at end of rows.	5m row-spacing between block of saltbush rows to allow stock movement and provision of supplementary feed. Occasional 10m wide track for vehicle access and fire fighting. Room to turn around at end of rows.	
Example understorey species	Lucerne (if low waterlogging risk). Balansa clover, tall wheat grass (if high waterlogging risk).	Burr medic (if low waterlogging risk). Balansa clover, puccinellia, tall wheat grass (if high waterlogging risk).	Volunteer understorey.	
Supplement-ation?	As required	As required	Yes, eg. hay, grain, lupins, stubble	

Mounding and drainage

Saltbushes are often grown on mounds to alleviate waterlogging (which can be a big killer of saltbush). However when mounds are formed on the contour (to minimise erosion potential) this can hold back water and lead to waterlogging or groundwater recharge. It is therefore recommended that mounds be installed on a slight slope (up to 2%) to allow water to be shed towards drainage lines.

For landholders looking at undertaking drainage activities, some important considerations are discussed in Section 6.1.3 (page 49).

Timing of planting

Waterlogging is a make or break issue for saltbush establishment. If the site is waterlogged or inundated, delay planting until the waterlogging has subsided. (However, if the frequency and duration of waterlogging is high, the site may not be suitable for saltbush.)

Selecting species

In Western Australia, the 3 most widely planted species are old man saltbush, river saltbush and wavy leaf saltbush, and these species are often sown in mixtures of equal parts by volume. The old man saltbush varieties ‘De Kock’ and more recently ‘Eyres Green’ (both selected for improved palatability) have been popular with South Australian producers.

Planting mixtures

Saltland can be variable, making plant selection difficult. Many successful growers in Western Australia plant mixtures of saltbush species and let the plants decide for themselves what will grow where.

6.2.2 Common causes of failure & how to avoid them

Weed competition

Plan ahead. Use a combination of chemical topping, cultivation and knockdown herbicides. Nitrogen fertilisers are not recommended at seeding as this will promote the growth of competing grasses.

Waterlogging

Provide adequate surface water drainage where possible. Plant saltbushes into mounds where necessary. Align mounds to provide some slope (up to 2%) towards drainage lines.

If the site is regularly waterlogged for significant periods it is probably not suitable for saltbush. Saltland sites receiving more than 450mm average annual rainfall will often be too wet for saltbush.

Insect pests

With direct seeding, red legged earth mite can kill seedlings before they emerge. Other pests can include aphids, lucerne flea and native bud worm. Monitor pests regularly and control with recommended insecticide.

Grazing too soon

Ensure proper fencing. Don't be tempted to graze too soon (allow up to 18 months for saltbush establishment).

Poor quality seed

Use tested seed from a reliable supplier. Adjust indicative seeding rates accordingly (refer to Recipe 2, page 59).

Unsuitable species

Select the most appropriate species for your location – seek advice (attend field days, contact your local revegetation contractors).

Very high to extreme salinities

At very high to extreme salinities production will be limited. Saltbush establishment is not recommended on these areas, which are largely naturally very saline. They should be managed for biodiversity values. Also see Section 6.1.2 (page 46).

Poor soils

Where soils are compacted or likely to restrict root growth, rip to at least 20cm.

On heavy clay soils production will be limited due to restricted water uptake by plants.

6.2.3 Establishment methods

Establishment methods

There are 2 ways of establishing saltbushes:

- ***Planting nursery-raised seedlings. (see Recipe 1, Section 6.2.4)***
    - Nursery raised seedlings are more versatile and generally provide the most reliable establishment method.
    - Establishment costs are generally higher: $250 to $500 per hectare, depending on plant density and cost of seedlings.
    - This method is suited to moderately low to high salinity sites (but not very high to extreme salinity).
    - This method is suited to a wide range of soil textures.
    - A tree planter or specialised vegetable planter is used.
    - This type of planting can occur with or without mounding. (But seedlings are best planted into a mound where waterlogging is likely to be an issue.)
    - An adequate tilth is required to give few deaths due to transplanting.

- ***Direct seeding (also called 'Niche seeding'). [see Recipe 2, Section 6.2.4]***
    - This involves growing saltbush directly from seed.
    - Establishment costs are cheaper: $150 to $300 per ha, depending on plant density, but the trade off is a reduction in reliability.
    - Direct seeding saltbush is suited to moderate to high salinity sites (but not very high to extreme salinity).
    - Direct seeding is most suited to sandy textured soils, or duplex soils with at least 10cm of sand over clay. Establishment is less successful on clay or hard setting soil as they will come up cloddy when mounds are formed.
    - A niche seeder is used. In a single pass the opposed disks on the seeder raises a bank, into which a V-shaped niche is pressed. This results in an elevated M-shaped mound. The seeder drops a 'placement' comprising a sample of saltbush fruits and a covering of around 50 mL of vermiculite mulch in the niche at the top of the mound. Placements are repeated every 1-3 m (depending on desired planting density).
    - The raising of the mound reduces waterlogging and the vermiculite acts as a mulch, minimising the movement of salt to the soil surface by capillarity.

6.2.4 Recipes for saltbush establishment

[Adapted largely from Barrett-Lennard and Phelan (in prep)]

RECIPE 1. Nursery raised seedlings.

Starting with nursery-raised seedlings can offer higher chances of establishment success, but at a higher price.

You will need:

- A saline site with up to high salinity (but not very high to extreme salinity).
- Saltbush seedlings. A mixture of old man saltbush and river saltbush is recommended.
- Seed of appropriate understorey species as required, such as inoculated annual legumes (eg. Frontier balansa clover, Scimitar burr medic, puccinellia, tall wheat grass).
- A knockdown herbicide and a spray rig.
- A means of cultivating the site.
- A tree planter to plant the seedlings.

Method (nursery raised seedlings):

1. In the year before planting – choose the site, plan the layout & control red legged earth mite.

   Choose a layout for the plantings (a dense stand or rows – see earlier Section 6.2.1 'Designing your saltbush system'), considering site salinity levels, widths of machinery, and other access issues. Ensure that mounds don't hold back the flow of water. Consider fencing and the provision of good quality drinking water for stock. Monitor and control red legged earth mites. [The Timerite® program (see website: www.timerite.com.au) is an excellent tool for managing RLEM.]

   LINK

2. Year 1 – planting the saltbush.

   Wait until the risk of waterlogging has abated (August – October). Apply a knockdown herbicide. Cultivate. Mark out saltbush rows and bays for the growth of understorey plants. Plant saltbushes. Monitor and control red legged earth mites for the understorey to be planted in Year 2.

   [Also see * below]

3. Year 2 – Planting the understorey.

   Apply knockdown herbicide after the break of season, being careful not to spray the saltbushes. Sow the understorey legumes (balansa clover and burr medic).

   * Where the understorey is to comprise perennial grasses such as puccinellia and/or tall wheat grass, these species require up to 18 months before they can be grazed. These species should be planted in Year 1, immediately after the saltbush is sown, and the combined saltbush/ perennial pasture will be ready for heavy grazing in the summer at the end of Year 2.

   Complete fencing and provision of stock water. Monitor and control red legged earth mite, lucerne flea, aphids and native budworm at establishment and again in spring.

4. Commencing grazing

   For dense saltbush stands with no understorey, light grazing can commence in the first autumn after planting (early in Year 2).

Alleyed stands with an annual legume understorey can be grazed lightly in the early spring of Year 2 (to control annual grasses) and can receive their first heavy grazing in the summer at the end of Year 2.

Costs (nursery-raised seedlings):

Costs include:

- Nursery-raised seedlings – 25 to 30 cents per seedling is common. Total cost will depend on planting density.
- Seedling transport costs.
- Cost for planting seedlings.
- Seed and sowing costs for understorey species if planting in alleys (eg. balansa clover, burr medic, tall wheat grass, puccinellia).
- Costs of spraying and cultivation.
- Costs of infrastructure (eg. fences, drains, water points).

RECIPE 2. Establishment from seed – using a niche seeder.

You will need:

- A higher salinity site (but not very high to extreme salinity).
- A sandy textured soil, or duplex soil with at least 10cm of sand over clay (soils in which mounds are easily formed).
- A mixture of saltbush species (river saltbush, old man saltbush and wavy leaf saltbush are often recommended).
- Good quality saltbush seed (fruit).

  Note: When direct seeding saltbush, the entire saltbush fruit is sown rather than just seed. However fruits (which occur on female saltbush plants) may, or may not, actually contain a seed. Where fruit do not contain a seed this may have been caused by long distances between male and female plants preventing cross-pollination, or plant stress during fruit development. The germinability of saltbush fruit is expressed as a % 'seed fill.'

  Because saltbush establishment from seed can be risky it is best to aim for 50 germinable seeds per placement (see 'Calculating saltbush seeding rates' below).

  Saltbush fruits keep well for several years if stored under dry conditions at room temperature.
- Vermiculite.
- Knockdown herbicides and a spray rig.
- A means of cultivating the site.
- A niche seeder.

Calculating saltbush seeding rates

The % seed fill in your saltbush fruits can be checked by:

- opening 10 to 20 fruits with a sharp knife to check the % of fruit that contain a seed, or

- get a laboratory to check the % seed fill (germinability) of your saltbush fruit.

A seed fill of 50% (ie. 50% of fruit have a seed) is good, while a seed fill of 5% is not.

The weight of saltbush fruit varies between species. Approximate numbers of fruits per gram for the major species are:

- Old man saltbush – 150 clean fruits per gram.
- River saltbush – 200 clean fruits per gram.
- Wavy leaf saltbush – 400-1000 clean fruits per gram.

To calculate the grams of saltbush fruits required per km of row, step through the following table.

Table 9. Calculating saltbush seeding rates (grams of saltbush fruit per km of row).

Step	Formula	Worked example
1. Determine % seed fill.	[% seed fill]	35% (from opening 10-20 fruit, or lab result)
2. Estimate number of fruit needed in each placement. (aiming for 50 germinable seeds per placement)	50 x 1/([% seed fill]/100)	50 / 0.35 = approx <u>140</u> fruit per placement
3. Estimate grams of clean saltbush fruit per placement	Divide above result by: • 150, for old man saltbush • 200, for river saltbush • 400-1000, for wavy leaf saltbush	For old man saltbush, 140 / 150 = <u>0.95</u> grams of clean fruit per placement
4. Estimate grams of fruit required per km of row.	Divide 1000m (1km) by the interval between placements to obtain the number of placements per km. Then multiply the result in Step 3 by the above result.	For 2m intervals between placements, 1000 / 2 = 500 placements per km. Then, 0.95 x 500 = <u>475</u>g of clean fruits are required per km of row.

For another example, lets assume we are planting river saltbush with a seed fill of 25%. Aiming for 50 germinable seeds per placement, we will need to apply 200 fruits per placement (50 / 0.25 = 200). River saltbush fruit weigh around 1/200g each, so we require 1 gram of fruits per placement (200 x 1/200 = 1). If placements are at 2m intervals then we will need 500 placements, or 500g of fruits per km of row.

Method (direct / niche seeding):

1. <u>In the year before planting – choose the site, spray-top, plan the layout & control red legged earth mite.</u>

   In the year before planting you should spray-top with a knockdown herbicide to prevent seed-set by annual grasses. Choose a layout for the plantings (a dense stand or rows – see Section 6.2.1 ‘Designing your saltbush system’), considering site salinity levels, widths of machinery, and other access issues. Ensure that when mounds are formed (with the niche seeder) they don't hold back the flow of water. Plan for fencing and the provision of good quality drinking water for stock. Monitor and control red legged earth mites. [The Timerite® program (see website: www.timerite.com.au) is an excellent tool for managing RLEM.]

2. Year 1 – planting the saltbush.

   For niche seeding, timing is critical. In wetter, southern regions germination and establishment will be impacted by the cold, and possible waterlogging. Wait until soil temperatures have warmed and the risk of waterlogging has abated (August-September). In drier northern regions, there is a risk that plants may not grow sufficiently to survive their first summer. Here, saltbush seed should be sown from July.

   Apply 2 knockdown herbicides (glyphosate 4 weeks before seeding and Sprayseed® 2 days before seeding – are recommended). Cultivate just prior to niche seeding. Do the niche seeding. After seeding monitor and control insects (red legged earth mites, aphids, aphids or native budworm). Check at weekly intervals for 10-15 weeks. More than 1 spray may be required.

3. Year 2 – Planting the understorey.

   Use the same method as for Recipe 1 (nursery-raised seedlings).

   Understorey clovers/ medics are planted in Year 2.

   Understorey puccinellia/ tall wheat grass are planted in Year 1 (immediately after planting the saltbush).

4. Commencing grazing

   Use the same method as for Recipe 1 (nursery raised seedlings).

Costs (direct / niche seeding):

Costs include:

- Saltbush seed – $40-80/kg for the 3 major species (old man, river & wavy leaf saltbushes). Total cost will depend on planting density.
- Hire of niche seeder. Contractor costs (can be around $150/ha)
- Vermiculite – about $15/ 100L bag.
- Seed and sowing costs for understorey species if planting in alleys (eg. balansa clover, burr medic, tall wheat grass, puccinellia).
- Costs of spraying and cultivation.
- Costs of infrastructure (eg. fences, drains, water points).

6.2.5 Management of saltbush based pastures

Grazing

As discussed in Section 6.2.4 'Recipes for saltbush establishment', grazing can commence as follows:

- ***For dense saltbush stands (no understorey)***

  Light grazing can commence in the first autumn after planting (early in Year 2).

- ***For alleyed stands with an annual legume understorey (eg. clovers, medics)***

  Light grazing can commence in the early spring of Year 2 (to control annual grasses) and the first heavy grazing can occur in the summer at the end of Year 2.

- ***For alleyed stands with salt-tolerant perennial understorey (eg. puccinellia, tall wheat grass)***

  Grazing of the combined saltbush and perennial pasture can commence in the summer at the end of Year 2.

Regular (yearly) grazing of shrubs prevents the shrubs from developing too much wood and produces the highest quality fodder. Over grazing or continuous grazing of shrubs will damage plants and reduce longevity.

Saltland pastures are best grazed during late summer to early autumn when annual pastures are in short supply and usually of low quality. This reduces the reliance on hay and grain to fill the autumn feed gap. However some feed supplementation is still likely to be required.

On its own, saltbush contains insufficient metabolisable energy (ME) [less than 8 MJ ME/kg] to satisfy maintenance requirements. And because it is a salty feed, animals limit their intake. This causes them to lose weight unless saltbush can be mixed with other low salt, higher energy feeds. A mixture of fodder shrubs (saltbush) and perennial grasses provides a good feed mix. The grasses provide the low salt, higher energy component and saltbush the high protein component. Feed supplementation is discussed further in Section 11.1.

Stock require access to ample quantities of fresh water when grazing saltbush due to the high salt content of the foliage.

Palatable versus unpalatable saltbush

Many saltbush plants can be less palatable than understorey (inter-row) pasture species or dry feed supplements. There are also usually large variations in palatability between saltbush plants, even within the same species and cultivar.

Traditionally producers have been encouraged to run high stocking rates (crash graze) for short periods of time in order to make stock consume a balanced diet of saltbush and more palatable feed (low salt, higher energy pastures or supplementary feed) and prevent preferential grazing on more palatable saltbush plants or understorey pasture species (eg. puccinellia). The conventional management practice has also been to remove stock once most of the leaf material from the shrubs has been eaten.

However, research conducted through the CRC Salinity (Franklin-McEvoy, 2007) suggests there may be penalties arising from forcing stock to consume unpalatable saltbush, particularly in young developing animals. This work has found that:

- When sheep are forced to graze unpalatable saltbush this appears to cause changes in rumen pH and micro-organisms.
- Nearly a 4-fold penalty in weight gain (112 g/day versus 32 g/day) was observed in comparative groups of 10 month old wether lambs (between ‘leaders’ who had the pick of feed on offer and ‘followers’ who grazed more unpalatable feed) during a 52 day grazing trial.
- In contrast, mature animals showed no significant penalty from eating unpalatable saltbush.
- At high levels of saltbush in the diet (over around 30%), animals incurred a penalty in performance.
- Reduced palatability in saltbushes appears to be associated with individual plants (ie. genetic or site characteristics), rather than as a response to being grazed.

The message from this is that producers should consider the class of stock and monitor animal performance measures (rather than focussing on plant performance), when determining optimum grazing levels.

6.3 PUCCINELLIA BASED PASTURES

Background

Section 5.4 contains background information on puccinellia (eg. site suitability, feed value, etc.).

6.3.1 Establishment of puccinellia

Site preparation

Fence the area to be sown. Grazing control is essential because establishing puccinellia plants are selectively grazed and are easily pulled out by sheep. Fencing also prevents sheep camping on the cooler salt-affected ground in summer. In some instances fencing may not be appropriate (eg. saltland occurs in small areas and/or is managed as part of larger paddock) and temporary electric fencing may be an option. Alternatively it may be convenient to renovate or crop the higher ground in that paddock in the same year with stock excluded from the larger paddock.

If waterlogging is a problem, shallow drains can be used to remove excess water. Diversion banks will reduce the movement of runoff water onto the area. Disposal of the drainage water (and impacts to downstream biodiversity and landholders) should be considered prior to drain construction. Important considerations for native vegetation and drainage are discussed in Sections 6.1.2 (page 46) and 6.1.3 (page 49). Also seek guidance from your regional NRM Board or DWLBC. Drainage should only be undertaken after expert advice has been sought.

Weed control

Weed control is critical to successful establishment. Sea barley grass zones with moderate waterlogging are often better suited to tall wheat grass pastures, but at high waterlogging levels sea barley grass extends into zones where puccinellia can grow well. Where puccinellia is established on sea barley grass land, it is essential that this weed be controlled, otherwise sea barley grass will compete strongly against puccinellia.

For controlling aggressive weeds such as sea barley grass, it is recommended that weeds are hit twice for adequate control. A spray-top in the spring prior to the year of seeding, and a knockdown herbicide at the break of the season should get on top of the sea barley grass population. Other options include burning, cultivation, or a combination of methods.

Other points of interest:

- Trials looking into herbicide control of sea barley grass in established puccinellia have shown that vacant spaces left after spray-topping of sea barley grass were often filled by a less productive salt tolerant weed, curly ryegrass, which itself is hard to get rid of. This highlights the importance of good weed control prior to establishment.
- Once the pasture has been established, ensuring adequate phosphorus levels and periodic applications of nitrogen will also increase the competitive ability of the puccinellia pasture sward against sea barley grass.

Cultivation

Cultivate in early autumn (Feb – Mar*), leaving a ridged or rough seedbed. [*Excepting sandy soils in low rainfall areas which should not be cultivated until after the break of season due to the risk of wind erosion.] A rough seedbed is particularly important for heavier soils or high salinities because:

- it allows opening rains to leach accumulated salts out of the soil surface;
- it prevents opening rains flattening the soil surface and creating a surface seal which impedes plant emergence;
- it reduces the incidence of sand blasting which can destroy young establishing puccinellia plants; and

- the slightly higher ground also provides a buffer against waterlogging and salt.

On sandier or moderately saline ground a high level of ridging/ roughness is less crucial, although can be of benefit on non-wetting sands (which do occur on saline flats in the South East).

Figure 9. Cultivation of saline creekflats (near Tumby Bay) prior to sowing puccinellia.

Sowing

Seek local knowledge as this will be invaluable.

Drop seed on the soil surface, or sow very shallow. This can be done with a small seeds box or mix it with superphosphate (up to 100 kg/ha) just before seeding and sow through the fertiliser box.

Avoid harrowing, particularly on heavy soils or high salinity sites. Trial work has shown up to a threefold depression in dry matter production in the first year of establishment if the seed is covered using trailing harrows.

On clayey soils – leave rough to assist in leaching of salt.

On sandier soils – a light rolling post-seeding may be beneficial for germination and establishment, through better seed-soil contact and moisture retention, but should be avoided where prolonged waterlogging is likely.

Timing of sowing:

- General advice is to sow in autumn as soon as possible after the opening rains.

  Wait for the opening rains to leach some of the accumulated salt out of the soil surface. On sea barley grass ground, wait for germination, spray, and then sow. Timeliness is critical and can make the difference between success or failure in pasture establishment.
- However, if the site is likely to become untrafficable after rains, dry sowing should be considered.
- In higher rainfall areas (above 475 mm) sowing in late winter to early spring has given promising results (depending on spring rains).

- In areas of lower rainfall, if opening rains have not come by early June, delay sowing until the next year. In most years, puccinellia sown after this time does not successfully establish.

Seeding rate

Sow at 4 to 10 kg/ha. Use the higher rate when sown alone, particularly where salinity is more severe, or where the influx of weeds is likely to be a big issue. The higher the seeding rate, the stronger the stand. Denser pastures will yield higher productivity. When sown in a pasture mix use 4 kg/ha or more.

From seed germination tests a small but significant percentage of seed may be ungerminated but can still be viable. This is classified as 'fresh ungerminated seed' and requires a period of extended flooding to germinate. Anecdotally, landholders in the Upper South East consider fresh ungerminated seed an essential and valuable component of the seed bank because of its survival qualities. This seed survives through false breaks and germinates after long flooding events (pers. comm. James Darling, USE saltland farmer).

Pests

Monitor and control red legged earth mite (RLEM) during establishment.

The Timerite® program (see website: www.timerite.com.au) is an excellent tool for managing RLEM.

Fertiliser (establishment)

Phosphorus levels should be tested to determine baseline levels. Puccinellia will benefit from phosphorus applications if P levels are below the critical level of 12 mg/kg (Colwell P). Soil extractable phosphorus levels above this are adequate for puccinellia. Phosphorus requirements will be higher if the site is capable of supporting clovers (> 20 mg/kg Colwell P).

Consideration should be given to the inclusion of companion legumes (where site conditions allow) to reduce the requirements for nitrogenous fertiliser application.

Nitrogen can be applied at seeding time but higher applications may largely dissipate before the nitrogen can be used by the slow-germinating puccinellia. Plant emergence can take as long as 2 months on bare saline scalds. However, more fertile sites provide the advantage of earlier grazing.

Whenever nitrogen is applied, the timing and risk of waterlogging are critical to success. Nitrogen may be lost if waterlogging occurs soon after application.

The use of MAP or DAP at seeding can be considered as a means of applying both nitrogen and phosphorus concurrently.

Maintenance fertiliser requirements are discussed in Section 6.3.2 'Management of puccinellia.'

Establishment downtime

Do not set stock until the end of the second year of establishment (about 18 months) to allow plants to properly establish, particularly if a lower seeding rate has been used. While it is preferable not to graze during this establishment phase, careful strategic grazing may be possible. Seedling puccinellia looks very fine and small but will thicken in subsequent years if allowed to set seed over the first summer. Where soil fertility is high and where higher seeding rates are used and/or pastures thicken up (and reseeding in the second year is less critical), early light grazing may be an option.

Mixed pastures

Puccinellia can be sown as part of a mix with tall wheat grass (with 4-10 kg/ha puccinellia and 10-15 kg/ha tall wheat grass) and clover (strawberry [1-2 kg/ha] and balansa [1-3 kg/ha]). Mixed pastures such as this also complement saltbush that has been established on saltland, adding considerably to the total grazing value of the stand. Where companion legumes can be established, pastures will benefit from additional nitrogen without the cost of applying fertiliser.

Figure 10 shows a paddock sown to puccinellia and tall wheat grass. Puccinellia grows on the central more saline and waterlogged zone, surrounded by the tall wheat grass zone.

Some producers choose not to sow puccinellia and tall wheat grass in the same paddock (usually where landscape/ salinity conditions are more uniform). The argument being that puccinellia (growing on highly saline sites) is best left standing during the heat of summer, while tall wheat grass will tend to become rank and clumpy if left ungrazed until autumn. Slashing to avoid this unwanted growth in tall wheat grass may be an option.

(a)

(b)

Figure 10. (a) [Photo taken Aug 2005] Despite being saline and subject to seasonal waterlogging and inundation, this land near Murray Lagoon on Kangaroo Island is still productive. (b) [Photo taken in Feb 2006] Puccinellia occupies the lower lying central area, surrounded by green 'Dundas' tall wheat grass.

6.3.2 Management of puccinellia

Grazing

Puccinellia can be grazed in a number of ways depending on the characteristics of each site and pasture system, seasonal conditions and other feed available on the farm.

Most economic benefit is usually gained if puccinellia is used to fill the late summer-autumn feed gap reducing the reliance on expensive supplementary feeding. Carrying over standing feed to be grazed dry in late summer-early autumn also shades the soil, preventing the build up of salinity through evaporation.

While feed quality declines as the plant dries off over the summer period, it still compares favourably with other dry pasture feeds through the summer-autumn period when feed is scarce. However, some supplementation may be required (see 'Feed supplementation' below).

Puccinellia plants shoot vigorously following the opening rains, and provide the best feed quality through winter to late spring. However, grazing on saltland requires flexibility, particularly where the degree of inundation can be unpredictable (eg. in parts of the Upper South East).

Where winter flooding is likely, puccinellia should be grazed carefully early in the season, to ensure plant shoots can remain above water. During winter flooding, stock can graze higher ground, retaining feed for summer-autumn.

Puccinellia stands commonly support 5 DSE/ha. With appropriate management and fertiliser application, dry matter yields can be doubled and stocking rates of 6-8 DSE/ha supported. At these stocking rates liveweight gains of over 120 kg/ha and clean fleece weights of over 20 kg/ha can be supported (Abraham et al., 2006).

Puccinellia seed is non invasive to animals so puccinellia paddocks can be used as a weed-seed free zone during the spring-summer period for sheep meat and wool production, provided the puccinellia pasture is well maintained.

Established puccinellia will tolerate hard grazing, but to maintain a vigorous stand, plants should be allowed to mature and set seed (along with nitrogen applied at the break of season or in spring, following winter grazing) at least once every two to three years.

Feed supplementation

The grazing value of puccinellia depends on its stage of growth. Green leaves in winter and spring have high protein content (15-25%) and high digestibility (60-75%), however this declines as the plant flowers and matures. It remains palatable in late summer and early autumn despite relatively low nutritive value (crude protein less than 5%, digestibility less than 50%). However, anecdotal evidence indicates that protein content in autumn is improved by longer durations of winter-spring flooding (pers. comm. James Darling, Upper South East saltland farmer). This is conditional on plants not being fully submerged and water not stagnating during the extended flooding. Mineral analysis has shown that several important nutrients (particularly phosphorus) and trace elements (particularly copper) also decline sharply over the summer-autumn period. Hence feed supplementation with hay, lupins, or grain, or grazing nearby lucerne, is often recommended to meet this seasonal shortfall in feed quality. Direct mineral supplementation can also be considered.

The best form of supplementation will depend on the particular feed value at the time of grazing and the type of stock. Lactating or growing animals require higher levels of metabolisable energy than other stock. During summer-autumn when puccinellia is low in protein and low in energy, lupins may be used to provide high protein and high energy. Extra hay may be sufficient for normal stock but usually won't provide enough energy for growing or lactating stock. Supplementary feed options and particular stock requirements need to be assessed on a case by case basis. Further information on feed supplementation is contained in Section 11.1.

Fertiliser (maintenance) & companion legumes

At higher salinities (where legumes don't persist), puccinellia dominant pastures will generally respond to nitrogen fertiliser.

The application of fertiliser to puccinellia pastures is one of the key management strategies to increase productivity in high salinity situations. [Note: Section 6.1.5 discusses important limitations to fertiliser responses.]

At moderate salinities, where legumes can be maintained, puccinellia will be receiving indirect nitrogen inputs from nitrogen fixing clovers/ medics. In this case superphosphate is used to maintain clover nutrition. In situations with a strong stand of clover in conjunction with puccinellia the nutritive value of both the green and dry feed is significantly boosted and can support liveweight growth.

However, with high salinities and/or waterlogging there is little opportunity for pasture legumes to contribute nitrogen to the system. Where legumes don't persist, puccinellia dominant pastures will generally respond to nitrogen fertiliser. However puccinellia will not respond to nitrogen without adequate phosphorus levels.

Phosphorus

Soil samples should be tested to determine baseline levels of phosphorus. Puccinellia will benefit from phosphorus applications if P levels are below the critical level of 12 mg/kg (Colwell P). Soil extractable phosphorus levels above this are adequate for puccinellia. Requirements will be higher if the site is capable of supporting clovers. Many farmers now use N-P fertiliser blends annually on established puccinellia stands.

Responses to nitrogen will not occur without adequate phosphorus. Equally, continued application of phosphorus fertiliser to soil with high basal P levels (e.g. > 20 mg/kg) has no additional pasture growth benefits.

Benefits of nitrogen & companion legumes

The benefits of nitrogen inputs are numerous.

- Increased productivity through the promotion of tillering and improved growth per tiller.
- Improved long term survival of puccinellia in harsh conditions. The plant is stronger, and more vigorous and able to tolerate higher levels of salt, flooding or waterlogging.
- Increased development of dormant tiller buds. These become tillers in the following year and this 'sets' the plant up for higher productivity.
- Increased feed quality. Digestibility is often increased but there is little effect on protein unless nitrogen has been applied above the growth demand of the plant.
- Increased seed production. This has a major impact if the pasture is harvested for seed.

Economic analyses from SGSL research indicates that nitrogen should be used strategically to fill feed gaps (e.g. early winter), rather than routinely. This is especially true in wool enterprises where the extra pasture and animal production do not always warrant the cost of N fertiliser and its application. The long term profitable productivity of puccinellia in these systems is dependent on there being sufficient legume in the pasture to fix nitrogen and meet the demands of the grass.

Timing of nitrogen application

<u>Fertiliser applications should be flexible and opportunistic</u>.

In established stands, nitrogen fertiliser can be applied at the break of season to boost autumn-early winter growth, while spring applications are undertaken to boost seed production or dry feed over summer-autumn. Whenever nitrogen is applied, the timing and risk of waterlogging are critical to success. Nitrogen may be lost if waterlogging occurs soon after application.

The best rate and timing of nitrogen fertiliser application depends on annual rainfall, and seasonal feed requirements. There are a number of strategies that can be used.

- ***Late autumn – early winter (May to early June).***

  Fertiliser is applied on the opening rains (within a week or so). Puccinellia will respond rapidly to the nitrogen while temperatures are still relatively warm.

  Advantages: A useful strategy to provide early feed or more grazing in winter. Allows other pastures to 'get away' while puccinellia is grazed.

  Disadvantages: Nitrogen may be lost if waterlogging occurs soon after application.

  From previous work in the Upper South East, application of nitrogen fertiliser in the late autumn – early winter period appears to give the best response economically (Morris, 2000), particularly for early winter feed. From a trial at Clover Ridge in the Upper South East, 25 kg N/ha (50 kg urea/ha) applied after the break of season (while conditions were still warm) gave an additional 150 kg DM/ha in 2 weeks and 300 kg DM/ha in 4 weeks. This was a 50% increase in pasture production over the period.

- ***Mid winter (July to early August).***

  This is the most appropriate strategy for drier areas (< 400 mm) that are unlikely to become excessively waterlogged and cause loss of nitrogen.

  In wetter areas, this late application does not necessarily work because soil temperatures are too low. (In wetter areas, earlier applications will be more responsive at higher temperatures prior to waterlogging, and will be more cost-effective for the late summer-autumn feed gap.)

- ***Late winter – early spring (August to early September).***

  A sound strategy to promote rapid growth in spring following grazing in winter, and provide adequate ground cover or dry feed over summer-autumn. It is also used to increase seed yield for harvesting.

- ***Split application in autumn and late winter.***

  Recent SGSL research has confirmed that this is the best option for maximal productivity, while anecdotal evidence suggests that seed production is also highly suited to this regime. The extra cost and time required to apply the fertiliser limits the widespread adoption of this strategy.

If the economics of your livestock system do not justify a boost of fertiliser on an annual basis, timely nitrogen fertiliser applications could still be used to advantage every 2 to 4 years.

Rates of nitrogen application

Economical rates are related to rainfall and intended use of the pasture (Table 10). Higher rates are economical if the pasture is used for seed production.

Table 10. Suggested rates of nitrogen fertiliser for puccinellia pastures.

Rainfall (mm)	350	400	450	500
Nitrogen (kg/ha)	15-25	20-30	25-40	30-50
Urea (kg/ha)	30-50	40-60	50-80	60-100

This table should be used as a guide only, as site and seasonal conditions will influence fertiliser responses and make it difficult to provide generalised advice.

Previous fertiliser trials (in the Coorong Districts and Upper South East) indicated the most cost-effective rate for early winter nitrogen application (a strategy to provide valuable early winter feed) was 25 kg N/ha (50 kg urea/ha) [Morris, 2000].

Previous work also found the most cost-effective rate for early spring applications, when nitrogen provides a boost to overall plant health and vigour (also helping stands compete better against sea barley grass) was 12 kg N/ha (25 kg urea/ha).

In contrast, SGSL trials at Mt Charles between 2003-2005 showed no significant responses in pasture growth below application rates of 25 kg N/ha (pers. comm. Nick Edwards, SARDI).

Rising fertiliser costs should also be factored in when making assessments of cost effective application rates. Section 12.2 'Pasture response to fertiliser calculator' provides a means to assess the economics of fertiliser application.

Forms of nitrogen

The form of nitrogen applied (urea, ammonium nitrate, sulphate of ammonia, etc.) appears to have little effect on overall response. Therefore the cheapest form, urea, is recommended. To avoid losses by volatilisation, urea should be applied to damp soil or just prior to rain. If this is not practical, apply urea late in the afternoon.

Weed control

Weeds, particularly sea barley grass and curly ryegrass, may become an issue in established stands of puccinellia. A farmer-initiated SGSL trial in the Coorong Districts (refer to link in Section 10.1) achieved some success in controlling sea barley grass and curly ryegrass through spray-topping.

From the products tested, the best performing spray-top herbicides were found to be:

- Paraquat (135g/L) and Diquat (115g/L) [Spray Seed ®] at 600mL/ha, and
- Paraquat (250g/L) [Gramoxone ® /Nuquat ®] at *400mL/ha, and *600mL/ha.

*Results indicated a trade-off between the rate (which in turn relates to cost) and the duration of effective weed control, for these top performing herbicides.

In this trial, herbicides were applied from the early tillering (Z23**) to head formation (Z52) and at the median soft dough stage for sea barley grass. [**From the Zadoks or decimal growth scale for cereals, refer to Smith (1998).]

While spray-topping of these weeds has proven successful, there is also a risk of curly ryegrass taking over the spaces left. This salt tolerant plant is also very competitive and even less productive than sea barley grass. Ensuring adequate phosphorus levels and periodic applications of nitrogen are useful tools to promote the competitive ability of the puccinellia against these weeds, particularly when used in conjunction with chemical control.

Renovation

Established pastures that have large bare areas can be roughly cultivated using an implement such as a cultivator with every second tine removed. This will provide suitable areas to trap seed and allow germination, without killing the existing stand. Cultivate only where significant bare areas are present. A single-tined ripper can also be used, especially along the edge of existing stands. Early autumn or late spring is the best time to undertake this operation.

Letting the puccinellia seed and mature, so that the seed drops, is another way to let the stand thicken up.

6.4 TALL WHEAT GRASS BASED PASTURES

Background information

Tall wheat grass (TWG) pastures are suited (ideally) to rainfall areas > 425 mm with moderate salinity and moderate waterlogging. Sea barley grass is a good indicator of ground suited to tall wheat grass. Most bare salt scalds are too saline to allow its establishment and growth.

Tall wheat grass is spring/ summer active and careful grazing management is required particularly when sown in pasture mixes with other species having different seasonal activity (eg. puccinellia grows from autumn to spring). Tall wheat grass should be grazed or cut to prevent it becoming a weed threat. This occurs if plants are allowed to go tall, rank and clumpy and set seed from January to March.

Section 5.4 contains further information on site suitability, cultivars and feed value.

Acknowledgement: A major source of information for this section on tall wheat grass establishment and management has been the Victorian Department of Primary Industries publication: ***"Management of tall wheat grass"*** (Borg, 2003).

6.4.1 Establishment of tall wheat grass

Site preparation

Fence the area to be sown.

If waterlogging is a problem, shallow drains can be used to remove excess water. Diversion banks will reduce the movement of runoff water onto the area. Disposal of the drainage water (and impacts to downstream biodiversity and landholders) should be considered prior to drain construction. Important considerations for native vegetation and drainage are discussed in Sections 6.1.2 (page 46) and 6.1.3 (page 49). Also seek guidance from your regional NRM Board or DWLBC. Drainage should only be undertaken after expert advice has been sought.

Weeds such as sea barley grass must be controlled. Best results are obtained by chemical topping the previous spring, followed by a knockdown kill of germinating weeds on the opening rains. Other options include burning, knockdown herbicide and cultivation. A combination of methods can be used.

Cultivate to roughly work the area up prior to the break of season (early autumn). This will enable the opening rains to leach some salts away from the surface.

Sowing

Timing of sowing:

- General advice is to sow in autumn after the opening rains. This allows for a kill of germinated weeds.
- In higher rainfall areas (above 475mm) sowing in late winter to early spring has given promising results.
- In areas of lower rainfall, if opening rains have not come by the end of June, the chances of successful establishment will diminish. Spring sowing accompanied by good follow-up rains can provide good results, but this is more risky.

Seed should be sown less than 1 cm deep. If sown separately, harrowing or light rolling will often aid establishment. When sowing with puccinellia, sow the tall wheat grass and some puccinellia through the main seed box, and drop the remainder of the puccinellia on the soil surface through a small seeds box. If separate seed boxes are unavailable then drop all seed onto freshly worked soil.

Importantly! - Do not harrow if sowing with puccinellia.

Companion species / pasture mixes

Companion species can include puccinellia, balansa clover, strawberry clover, persian clover, tall fescue and lucerne, depending on average rainfall and other site conditions.

Example recommended mixes include:

- ECe: <5 dS/m: TWG, tall fescue*, strawberry and balansa clovers.
- ECe: 5-10 dS/m: TWG, strawberry and balansa clovers.
- ECe: 10-20 dS/m: TWG and puccinellia.

[*However, Victorian trials have shown that Resolute and Advance tall fescue will germinate and grow at ECe levels up to approximately 8 dS/m, losing up to 50% of productivity at this higher salinity level (pers. comm. Dion Borg, Vic DPI).]

Under favourable conditions, legumes (eg. strawberry and balansa clovers) will compete strongly with the young tall wheat grass seedlings. In these situations, good results have been achieved by sowing pasture legumes a year or two after the grasses.

When sown in a mix some species may colonise different zones (eg. tall wheat grass and puccinellia, see Figure 10, page 66). Grazing management will need to be carefully considered where pasture species have different seasonal activities. In particular, tall wheat grass and balansa clover systems are discussed further below.

Seeding rate

The higher the seeding rate, the stronger the stand. The following rates are recommended:

- 15 to 20 kg/ha if sown alone.
- Use 10 to 15 kg/ha if sowing with puccinellia. [*Sow puccinellia at: 4 to 10 kg/ha.]
- Use 4 to 5 kg/ha in a mixture with other grasses/ legumes. [#Sow other grasses/ legumes at, for example: medics - 2 kg/ha, clovers - 0.5-2 kg/ha, lucerne - 2 kg/ha, phalaris - 2 kg/ha]

#See Table 12 (page 79) for a further guide to seeding rates for other pasture species when sowing tall wheat grass in a mix.

Check that tall wheat grass seed is less than two years old as seed viability drops rapidly after two years. Seed viability/ germination tests are also recommended. 50-90% germination should be expected for viable seed and sowing rates should reflect this.

Pests

Monitor and control red legged earth mite (RLEM) during establishment.

The Timerite® program (see website: www.timerite.com.au) is an excellent tool for managing RLEM.

Fertiliser (establishment)

Soil tests are recommended. If the site is eroded or has poor fertiliser history, apply 9 to 14 kg P/ha or equivalent (eg. 100 to 150 kg/ha of superphosphate) at sowing. Nitrogen fertiliser applied in late winter to early spring will boost productivity and help maintain plant palatability. Apply 20 to 50 units of N per ha (about 40 to 100 kg/ha of urea).

Establishment downtime

See 'Management of new stands (1st year)', below.

Light grazing may be possible in the spring of the first year (following autumn establishment) in low salinity zones, without spring waterlogging, and where seedlings are firmly anchored.

In moderate or higher salinity zones (ECe > 5 dS/m), seedlings will take longer to establish and may need to be spelled from grazing, or only grazed lightly, until the end of the year following establishment.

Generally, allow about 12 to 18 months (from autumn establishment to the end of the following year) for plants to establish before set stocking.

6.4.2 Management of tall wheat grass

Tall wheat grass (TWG) is summer active with most growth occurring from late spring onwards. It sets seed from January to March and this period corresponds with a decline in feed quality. Grazing or cutting to avoid poor quality mature stems at this time, will minimise feed quality losses (rank pasture), however some decline will occur even when pastures are kept short. Despite this decline in quality, it is often the only green feed available at this time and still valuable when compared to costly supplementary feed.

For tall wheat grass, pasture height is a major determinant of feed quality. Pastures kept grazed below 20cm are high quality pastures providing equal or greater feed value than phalaris or annual ryegrass pastures (see Table 11).

Table 11. Tall wheat grass mean feed quality results for spring 2002, from 9 properties across southwest Victoria (Borg and Fairbairn, 2003).

Pasture Height	Crude Protein (% dry matter)	Digestibility (% dry matter)	Metabolisable Energy (MJ/kg)
< 20cm	18.9	75.3	11.0
20cm – 1m	15.2	66.4	9.6
> 1m	7.6	52.4	7.4

In summary:

- Established pastures should be stocked heavily during late-spring and summer to prevent plants from becoming rank and losing nutritional value. This also prevents the spread of tall wheat grass seed and offsite weed issues. Where grazing is not possible during this time (eg. in mixed pastures being spelled to protect more palatable species from overgrazing), slashing of tall wheat grass may be an option.
- Management is easier with cattle than sheep.
- Tall wheat grass that has become unacceptable to stock can be improved by slashing. However mature TWG can be hard on machinery.

Balansa clover & tall wheat grass

Balansa clover complements the tall wheat grass system by providing late winter feed. Both plants also require hard grazing in late spring / summer after the balansa clover has set seed.

Management of new stands (1st year)

Tall wheat grass is a weak seedling, but persists well once established. Careful grazing is required in the first year to maintain leafiness and optimise establishment rates.

Fertiliser (1st year)

Following autumn establishment, top-dress the new tall wheat grass pasture with up to 100 kg urea/ha in spring. TWG has a high requirement for nitrogen and phosphorus if optimum productivity is to be maintained. Both nitrogen and phosphorus are limiting in most saline areas. Where legumes are able to persist, they should be able to supply most of the nitrogen needed in the following years.

Grazing (1st year)

Sites with low salinity levels (< 5 dS/m) without spring waterlogging can be lightly grazed in early September if TWG seedlings are firmly anchored to the ground. Simply pulling at the seedlings to see how well they're anchored can test this. If seedlings are easily pulled out then grazing should be deferred.

Points to note:

- Do not graze if seedlings are not anchored or the site is waterlogged.
- If sown in a mix with balansa clover, stock should be removed from the paddock while the clover is flowering (timing will depend on particular cultivar). Failure to do this will result in reduced clover seed set and regeneration the following year. This first year is critical to establishing a good seed bank.
- Crash graze the pasture after balansa seed set (timing depends on particular cultivar) down to 10cm. This removes excess growth, helps control weeds, encourages better leaf growth and makes grazing management easier over summer.
- Lightly graze over the summer-autumn period down to 5cm. This promotes strong root development and water use, removes excess trash and provides favourable conditions for the balansa clover to regenerate.
- Do not graze the pasture over winter if the site is waterlogged.

Sites with moderate or higher salinities (> 5 dS/m) may need to be grazed lightly or spelled from grazing until the end of the 2nd year (around 18 months following the autumn sowing) to optimise establishment rates. In this scenario other management options (such as slashing), to prevent TWG from seeding need to be considered.

Management of new stands (2nd year and after)

Fertiliser (2nd year and after)

Where legumes persist, these should provide most of the nitrogen needed for pasture maintenance. Where legumes don't persist, annual nitrogen applications of 25 to 50 kg N/ha are suggested. Actual applications should be determined by soil testing and cost-effectiveness. A soil test should be considered every 3-5 years to verify fertliser needs.

To maintain the productivity of TWG stands, up to 9 kg P/ha (in high rainfall areas) should be applied annually. Critical soil test exchangeable P levels for tall wheat grass (below which, responses to N will be limited, and above which further P inputs will be largely wasted) are not specifically known. However data from the Victorian Department of Primary Industries (Vic DPI) suggests that critical P levels for a large range of perennial grasses is around 12-14 mg/kg (Olsen P). This is roughly equivalent to 24-28 mg/kg (Colwell P). From South Australia, it is anecdotally reported that where clovers are maintained, soil P levels should be > 20 mg/kg (Colwell P). Vic DPI research indicates that the amount of phosphorus per DSE needed to maintain productivity varies from 0.42 to 1.46 kg P/DSE/yr, depending on rainfall, soil type, pasture species and grazing management (Cayley and Quigley, 2005).

LINK

Vic DPI have produced an information booklet – ***"Phosphorus for sheep and beef pastures"*** (Cayley and Quigley, 2005) – to help producers assess how much phosphorus is likely to be needed to maintain productive pastures.

This enables estimates of annual P inputs per DSE, for different rainfall zones, soil and landscape types, grazing management and poor or improved pastures.

See the website: www.dpi.vic.gov.au or the PDF copy on the CD-ROM, or contact Vic DPI – Hamilton on (03) 5573 0900.

Grazing (2nd year and after)

Winter to early-spring grazing, in non-waterlogged sites, will make use of other components of the pasture mix such as balansa clover. At the first sign of balansa flowering, careful grazing of the pasture is required. At this time, pastures should not be crash (heavily) grazed to ensure adequate seed set and retention of the legume base. Experience in the South East of South Australia has shown that moderate stocking rates during flowering (which also corresponds to a period of high growth) has enabled adequate seed set and regeneration. Notwithstanding this, the pasture composition should be monitored and where the legume component is not regenerating it may be necessary the next year to further limit or stop grazing from flowering until seed set is complete.

Once balansa clover seed set is complete (timing dependent on particular cultivars) the stand can be crash grazed to remove excess balansa growth and TWG stems which will have started to run up to flower.

Continue grazing throughout summer and into autumn to maintain a pasture height below 10cm until the paddock becomes too wet for stock. Management to prevent seeding maximises pasture quality and reduces the risk of spread of TWG from the site.

If stock selectively graze areas, increase stocking rates or set up electric fences to force grazing. Crash graze the pasture to a uniform height of less than 10cm to prevent pasture going rank and clumpy.

Reclaiming old tall wheat grass stands

Left unmanaged, TWG can form unproductive monocultures of erect clumps up to 2m high. These are of little grazing value and pose a risk of spreading seed to areas where TWG may become a pest. However options are available to return these stands into production and remove the threat to the environment. Options include cutting or burning, and should be undertaken as the plants are sending up flowering stems. Cutting to a height of 10cm maximises trash removal and protects the plant crown. However it should be noted that working in old TWG paddocks can be hard on machinery. Techniques include:

- Mulching – this is the ideal technique, breaking stems into smaller segments to allow for quicker breakdown of trash. However specialised mulching machinery is not always available.
- Slashing – is often the more achievable option, but is not ideal as trash is left in a heavier mat, which takes longer to break down and tends to smother the pasture regrowth.
- Burning – which achieves the same purpose to remove all old growth.

Grazing and management should then follow recommendations for managing new stands (2nd year and after).

Most old stands have no legume component in the pasture sward. If a high quality pasture is desired, legume content is critical. Where salinity levels allow, balansa clover seed can be broadcast with the fertiliser in early autumn. If soil conditions permit, and providing rank grass is removed and some bare ground is visible between plants, balansa clover will readily germinate.

Fodder conservation

Tall wheat grass may be cut for hay or silage. Cutting prior to heading will maximise feed value.

Escape weed potential

Tall wheat grass has the potential to spread into natural saline wetlands, grasslands and roadsides, competing with and threatening native plant communities.

It is not recommended for establishment in or adjacent to natural saline areas or native vegetation.

Grazing down to 10cm in the summer-autumn period will avoid seed set, minimising the risk of spread.

6.5 SPECIES FOR HIGHER CAPABILITY SALTLAND

As discussed in Section 5.5, these species will be suited to low to moderate salinity conditions and a range of waterlogging conditions.

Knowledge of the establishment and management practices for these more traditional pasture species is likely to be more widespread than for more salt-tolerant species, and given the large range of species suited to a range of conditions, it is not appropriate to discuss them all in this manual.

Instead landholders should refer to the following resources:

- Section 5.5 'Species for higher capability saltland'.
- Section 3.1 'How do I select the right plants – a step by step approach'.
- Section 6.1 'Establishment & management – general principles'.
- Local advice from growers, agronomists, seed merchants and field days.
- Vic DPI Fact sheet – ***"Pastures for discharge areas"*** (Borg, 2005), available online at www.dpi.vic.gov.au/notes > Crops & pastures > Pastures (general) > Pastures for discharge areas [copy on CD-ROM].
- ***"Pasture plus: the complete guide to pastures,"*** published by the Kondinin Group (Casey, 1995).
- ***"Pasture legumes for temperate farming systems: the ute guide"*** (Wurst et al., 2004) [available from the Roseworthy Information Centre, Freecall: 1800 356 446, or online bookshop: www.ruralsolutions.sa.gov.au/bookshop].
- ***"Success with lucerne"*** (Stanley et al., 2002) [available through PIRSA / Rural Solutions SA offices, or the Roseworthy Information Centre, as above].
- ***"Lucerne prospects: drivers for widespread adoption of lucerne for profit and salinity management,"*** published by the CRC Salinity (Robertson, 2006).
- ***"Making lucerne pay: integrating crops and lucerne on mixed farms"*** (Vic DPI, 2006) [Available through Vic DPI Bendigo, phone: 03 5430 4451 or online at www.grdc.com.au/bookshop/sale.htm]
- PIRSA Fact sheet – ***"Permanent pasture mixtures for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island,"*** (Fairbrother et al., 1999) [copy on CD-ROM].
- ***"Greener Pastures for South West Victoria"*** (Nie and Saul, 2006), including Chapter 10 'Managing pastures in saline areas' (McCaskill and Borg, 2006), Published by the Victorian Department of Primary Industries.
- Grassland Society of Southern Australia Inc. website, including a pasture species database, at: www.grasslands.org.au .
- ***"Saltland pastures in Australia: a practical guide"*** (Barrett-Lennard et al., 2003).
- The pastures information guide available on the CD-ROM prepared by Tim Prance, Senior Consultant Pastures & Grazing Systems, Rural Solutions SA. This guide contains information on pasture identification, growing seasons, preferences for rainfall, soils and pH, companion species and planting.

6.6 PASTURE MIXES

As discussed in Section 5.6, a mix of pasture species will often be the best bet for maximising production on undulating or variable salinity and waterlogging saltland.

Producers seeking establishment and management information for a range of pasture species (including pasture mixes) can seek information through:

- Sections 6.2 to 6.4 – for more salt-tolerant species (saltbush, puccinellia and tall wheat grass).
- Section 6.5 – for species suited to lower salinity (higher capability) land.
- Section 6.1 – for general principles of establishment and management.
- Gaining local advice from other producers, agronomists, seed merchants, or at field days.

Determining the species mix

The optimum species mix can be determined by:

- Referring to Section 3.1' How do I select the right plants – a step by step approach.' In particular see Figure 2 (page 15), Table 2 (page 14) and investigate the preferred conditions for different species (eg. rainfall, pH, soil type) as discussed in Section 5.
- Identifying the different niches (conditions of salinity, waterlogging, etc.) on your site. For perennial species, assess peak soil salinities in summer-autumn. Significant 'high' versus 'low' areas are likely to need different pasture mixes.
- Allowing for some variation in seasonal conditions.
- Considering feed quality and grazing management issues.
- Consulting with local producers, agronomists and/ or seed merchants.
- Trial and error, to see what works.

Seeding rates

Seeding rates for some pasture grasses and legumes used in mixes are listed below (Table 12).

Grazing management

'Shotgun mixes' can potentially cause difficulties in grazing management where different species are active and set seed at different times of the year. In contrast, single pasture (and legume) systems are easier to manage and usually preferable where they can be established.

Mixed pastures should be rotationally grazed to maintain the persistence of the most susceptible / palatable species. This is often lucerne (where present), or puccinellia. This grazing regime may mean that tall wheat grass (where present) will become rank. Cattle will graze tall wheat grass better than sheep if it gets into this state. Alternatively tall wheat grass can be slashed to improve feed quality and reduce weed risk.

Salinity management

In and around saline areas recharge is an important issue. Maintaining high quality perennial pastures where possible is recommended as part of the overall salinity management strategy. Depending on soil type and rainfall, lucerne may be the preferred perennial, but perennial grasses in combination with annual legumes also have high water use potential for assisting with catchment/ salinity management.

Table 12. Recommended seeding rates for pasture species in mixes.

Variety	Seeding rate (in a mix)
Tall wheat grass*	10-15kg/ha with Puccinellia, 4-5kg/ha with other grasses/ legumes.
Puccinellia	4-10kg/ha
Phalaris	1-2kg/ha
Tall fescue	4-5kg/ha
Annual ryegrass	2-6kg/ha
Balansa clover	1.0-3.0kg/ha
Spineless burr medic	2-5kg/ha
Sub clover	3-10kg/ha
Strawberry clover	1-2kg/ha
Persian clover	1-2kg/ha
Lucerne**	2kg/ha

Notes:

- The suitability of any particular pasture species to a pasture mix will depend on soil and climate conditions (see Section 5) along with potential grazing management issues.
- *Lower seeding rates (down to 6kg/ha) necessitate letting the tall wheat grass go to seed to thicken the stand and parent plants to become tussocky – however this leads to an increased risk of weed issues.
- Experience has shown that in the case of both puccinellia and tall wheat grass, the higher seeding rate the better.
- **Lucerne will only persist in areas at low risk of waterlogging. However some producers frequently re-establish lucerne in areas with relatively shallow watertables because of the plant's desirable feed quality and production values. Self-harvesting seed may make this an economically viable option.
- Pasture legumes should be inoculated as recommended prior to sowing.

7 MEASURING SALINITY

7.1 WHAT IS DRYLAND SALINITY?

Salinity refers to the presence of dissolved salts in soil and water. Salinity can be natural ('primary' salinity) or due to human-induced changes ('secondary' salinity).

Primary salinity dominated sites are characterised by naturally very high to extreme salinity, salt-tolerant vegetation and/or bare scalds. The salinity in these sites is historical, being present prior to the development of the land for agricultural purposes. These areas will have poor productive potential and should be left in their natural state to be managed for environmental values. It should be noted that native vegetation (including samphire), on either primary or secondary salinity sites is protected under the *Native Vegetation Act 1991*. However, situations where approval for native vegetation clearance may be granted are discussed in Section 6.1.2, page 46.

Secondary salinity dominated sites occur where degradation has been largely caused by land use change. The term 'dryland salinity' is commonly equated with secondary (human-induced) salinity associated with shallow watertables, in non-irrigated areas. These areas are the focus for establishing saltland pastures (to help reclaim significant areas of the farm that otherwise appear lost to salinity), and hence the focus of this manual.

Other types of salinity (eg. dry saline land, which occurs without the influence of a watertable) are discussed in the Glossary.

What is the cause of human-induced dryland salinity?

The shallow rooted crops and pastures that now dominate our landscapes use less rainfall than the original native vegetation. This has caused a shift in the water balance, mobilising naturally saline groundwater or salts that were previously stored in the landscape to areas where they cause a problem. When recharge to groundwater increases, over time, this has to be matched by a rise in watertables and/ or increasing groundwater discharge to streams or surface soils. Where watertables rise close to the surface, capillary action can bring salts into the root zone and evaporation causes salts to concentrate. Low-lying or poorly drained areas are the most susceptible, and salinity can spread from areas of natural / primary salinity.

Indicators of salinity can include:

- Dieback of mature trees.
- Waterlogging caused by groundwater seepage.
- Patchy crop and pasture establishment, and reduced yields.
- Poor or failing pasture legumes (eg. loss of clovers and medics).
- Emergence of sea barley grass, samphire and other halophytes (salt loving plants), bare ground and salt crystals.


Shallow saline groundwater (shown in this clay pit) causes salinity problems at the surface.

How can we manage it?

Actions to control salinity will generally fall into three areas:

- Recharge reduction – using more water where it falls.

- Living with salt – where management will depend on the extent and severity of salinity.
- Engineering – eg. improving drainage (including avoiding stagnation of surface water).

The best approaches to managing salinity often have actions from all three areas, and try to address the whole catchment area contributing to the problem. The effectiveness of different management options will depend on where a property is situated and the type and scale of groundwater flow system.

7.2 SALINITY IS VARIABLE – IN SPACE AND TIME

Salinity is variable: across the paddock; through the year; and between years. Appreciating this variability is an important step in selecting the appropriate pasture mix to maximise production.

Figure 11 displays variability in salinity across a paddock, as measured by a ground electromagnetic (EM) survey. Noticing various indicator plants is another way to identify different salinity zones.

Salinity also varies with the seasonal cycles as shown in Figure 12. Salts are flushed with rainfall and build up with capillary action and evaporation. By covering the ground, saltland pastures help to reduce peak salinity levels in summer.

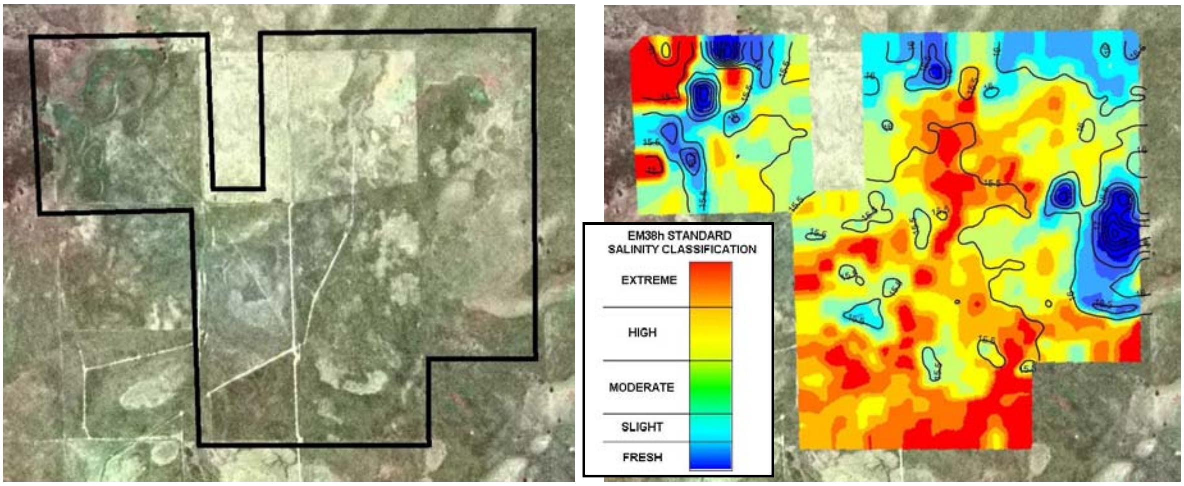


Figure 11. Varying salinity across a paddock, indicated by a ground EM survey.

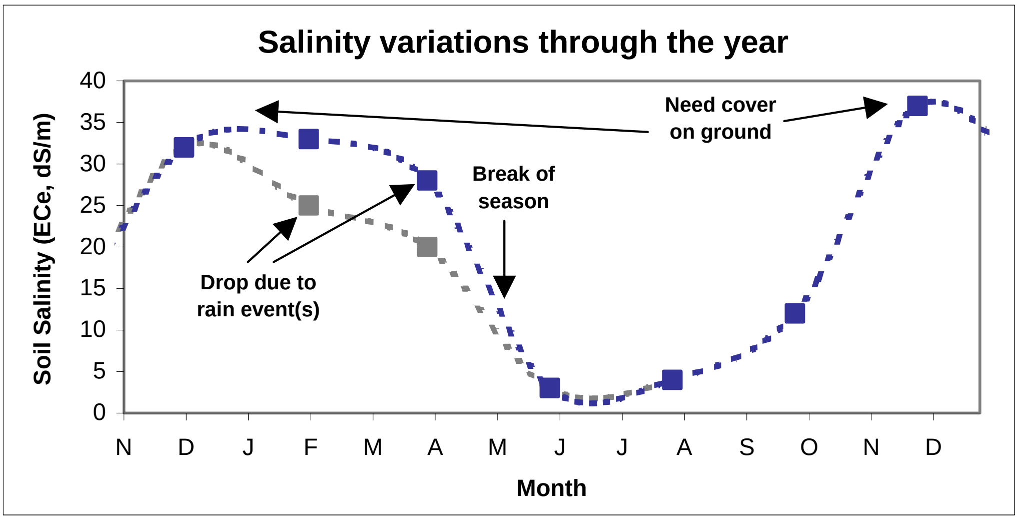


Figure 12. Example of seasonal trends in surface soil salinity. (Large seasonal fluctuations, especially in surface soil, such as this are often found in parts of the Upper South East.)

Dryland salinity also varies between years, as groundwater levels are heavily influenced by rainfall trends. Figure 13 shows groundwater levels in discharge zones of three adjacent sub-catchments in the Mt Lofty Ranges, each with a different land use. A period of lower than average rainfall and higher water use in the sub-catchments under trees and lucerne, have caused major reductions in salinity by lowering the watertable. [The rainfall trend (blue) in Figure 13 is the cumulative deviation from mean monthly rainfall. Upward trends indicate consecutive months when the monthly rainfall is above average, while downward trends indicate consecutive months of below average falls.]

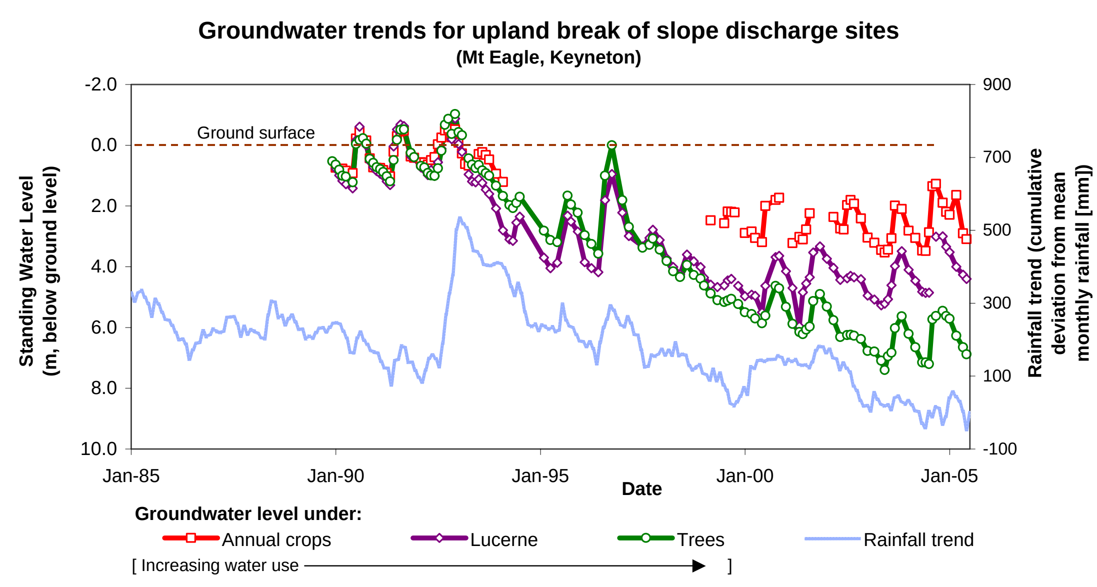


Figure 13. Groundwater trends are influenced by rainfall and differences in catchment water use (eg. annual crops, lucerne and trees).

7.3 HOW ARE SALINITY LEVELS DEFINED?

There is no easy way to define different levels of salinity. It is usually done using a combination of:

- Plant and landscape indicators,
- Soil salinity measurements (surface and subsoil), and
- Depth to groundwater measurements (if available).

> Salinity levels are best defined using a combination of indicator plants, soil salinity (EC) and depth to watertable measurements.

In South Australia, 7 classes of salinity have been defined (as shown in Table 13). Areas of land can be assigned to the different salinity classes using each of the indicators as a guide. However, no single indicator should be used on its own. Figure 14 provides a visual guide to how the depth to a saline watertable can impact on salinity levels and the persistence of different plant species.

Measuring peak soil salinity (between mid summer to mid-autumn) provides a standard measure of soil salinity. However it is worth bearing in mind that salinity is a dynamic thing, changing through the year and between years. Salt can be very mobile, with water providing the transport mechanism. Soils, geology, drainage, rainfall and the type of groundwater flow system will influence the range of salinities possible and how quickly changes can occur.

Assessing the levels of salinity (and also seasonal changes) on your saltland will assist in identifying suitable saltland pasture options (as discussed further in Section 3 'How do I select the right plants?').

Table 13. Indicative salinity levels and capability (productive potential) of saltland.

*Saltland Capability	Salinity Level	Vegetation & landscape indicators	Other classification criteria: #Depth to saline watertable	Other classification criteria: ##Indicative ECe (dS/m)
	Low	No evidence of effects of salt	No influence	< 2 (surface) < 4 (subsoil)
High	Moderately Low	Subsoil salinity – deep rooted horticultural species & pasture legumes affected.	Usually deeper than 2 m.	< 4 (surface) 4-8 (subsoil)
	Moderate	Many field crops & lucerne affected. Halophytic species such as sea barley grass are usually evident. Yield losses in wheat.	Shallower than 2 m, capillary effect reaches into root zone.	4-8 (surface) 8-16 (subsoil)
	Moderately High	Too salty for most field crops & lucerne. Halophytes are common (as above plus curly rye grass and salt water couch). Strawberry clover productivity is diminished. Unsuitable for wheat. Yield losses in barley.	Seasonally within 1 m of the root zone.	8-16 (surface) 16-32 (subsoil)
	High	Land dominated by halophytes with bare areas. Samphire & ice plant evident. This land will support productive species such as puccinellia & tall wheat grass, etc.	Seasonally near the surface.	16-32 (surface) > 32 (subsoil)
	Very High	Land is too salty for any productive plants & supports only samphire, swamp tea tree or similar halophytes.	Near the surface most of the year.	> 32 (surface)
Low	Extreme	Bare salt encrusted surface.	Near or at the surface most of the year.	> 32 (surface)

Notes:

- These salinity classification criteria were developed by the South Australian Department of Water, Land & Biodiversity Conservation (DWLBC).
- *The term 'saltland capability' is discussed in Section 4.1.
- ***Sometimes indicators can be misleading:***
  - #Depth to watertable may be an unreliable indicator of salinity if groundwater is fresh, for example as found in parts of the South East region.
  - ##Soil salinity measurements can be unreliable following rainfall events. Values shown in the table are considered to be the peak soil salinities found during summer-autumn. [The quantity 'ECe' is discussed in Sections 7.4 & 7.5.]
  - Indicator plants may be impacted by other factors, aside from salinity (eg. waterlogging, pH, etc.). Actual species present will vary between regions. Different varieties of a species may vary in their salinity tolerance.
  - EM38 measurements can also be used to gauge salinity levels, however conductivity readings are averaged over the measurement depth (0-60cm or 60-120cm) rather than just in the plant root zone.
- A combination of the indicators shown above help to define the salinity level.
- Photos of example landscapes from each of the salinity classes are provided in Section 8.

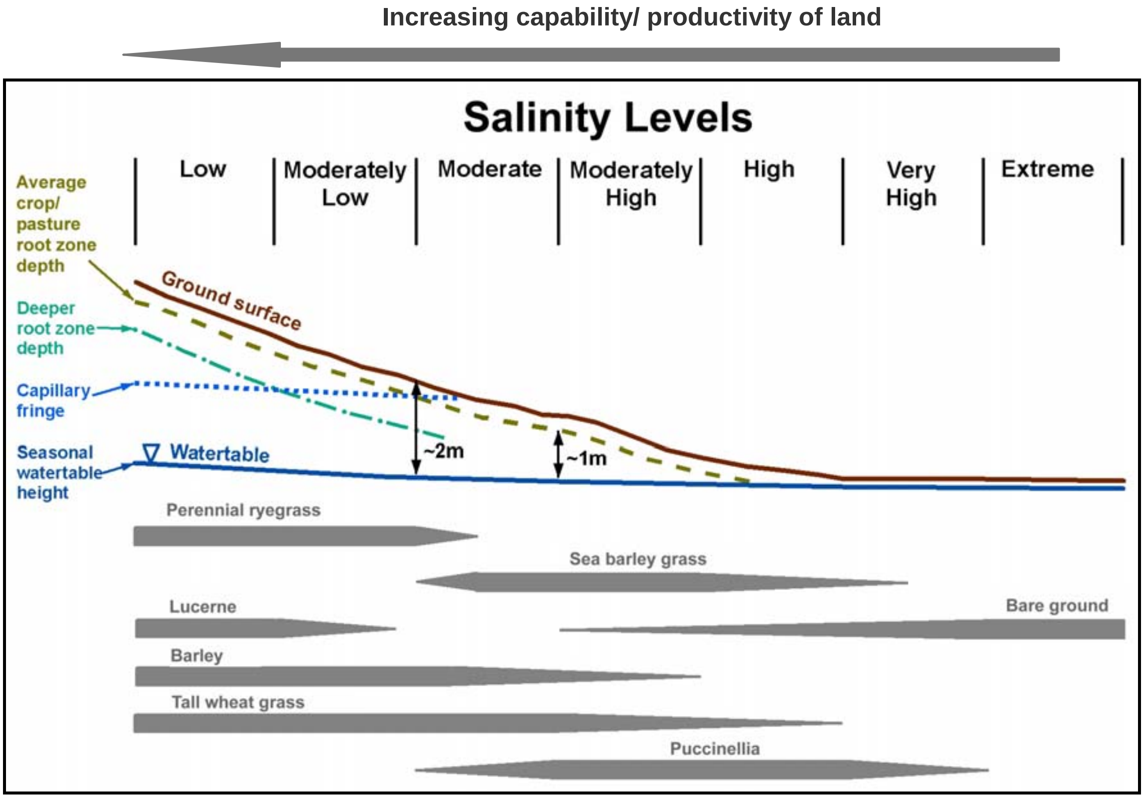


Figure 14. How depth to a saline watertable can influence salinity levels and the persistence of different plant species (also see Table 13 and accompanying notes).

7.4 COMPARING DIFFERENT SALINITY UNITS

Any measurement of salinity, whether it is surface water, groundwater or soil salinity, will refer to an amount of salt dissolved in water. Soil salinities are associated with salts that are available to be mobilised when a soil becomes saturated.

There are a number of different ways to express measurements of salinity:

- ***Chemical composition.***

  Measures of chemical composition are expressed in parts per million (ppm), milligrams per litre (mg/L) or grains per gallon (gpg).

  Values of 'mg/L' and 'ppm' are numerically the same (1 mg/L = 1 ppm), and quantify the milligrams of salt per litre of water.

  'Grains per gallon' (gpg) is an older, less common unit, where 1 gpg = 14 ppm = 14 mg/L.

- ***Electrical conductivities (EC).***

  Measures of EC (eg. 'ECe' and 'EC 1:5' – which are defined in the following section) are usually expressed in decisiemens per metre (dS/m).

  While the dS/m is the standard unit for EC measures of soil salinity, a number of other units are in use around the world. These can be related to each other via the table below.

Table 14. Salinity units – relating the 'dS/m' [decisiemens per metre] to other common units.

1 dS/m =	1 mS/cm [millisiemens per centimetre]
1 dS/m =	100 mS/m [millisiemens per metre]
1 dS/m =	1000 μS/cm [microsiemens per centimetre]
1 dS/m =	1000 'EC units' [a non-scientific but popularly used unit]
1 dS/m =	*640 ppm = 640 mg/L

*Note: Measures of the electrical conductivity (EC) of a water (or soil-water) sample can be converted to ppm or mg/L based on an estimate of the chemical composition of the salts in the water. The conversion factor will vary markedly for different types of salts.

The factor 640 is a widely used average value for South Australia, based on the analysis of a large number of different water sources. If the salts in water are mostly sodium chloride the conversion will be closer to 500; if the salts are mostly gypsum or bicarbonates the factor will be around 800 or 900. Laboratory analysis (conducted once only for each source of water) will determine the relative composition of salts and provide an accurate conversion factor.

7.5 HOW DO I MEASURE SOIL SALINITY? (EC 1:5 & ECE)

Why do I need to measure my soil salinity?

Measuring soil salinity (usually an ECe value) is an important part of determining salinity levels. This is because plant indicators can often be confused with other causes:

- Poor pasture performance can be related to nutrient deficiencies, soil properties or herbicide damage.
- The presence of salt indicator plants (eg. sea barley grass, samphire) may be partly due to waterlogging issues.

Therefore, soil salinity measurements (specifically, in the plant root zone) are an important counterpart to indicator plant species in defining how salty a soil is. This will save you money, helping in the selection of appropriate salt-tolerant species, and avoiding expensive mistakes.

What are ECe and EC 1:5 values?

There are two ways to measure soil salinity: one is accurate but more expensive (ECe); the other is approximate and low-cost (EC1:5). For our purposes the low-cost method is sufficient, but some understanding of the more expensive method is needed.

It is common practice for salinity to be inferred from measurements of the electrical conductivity of salts dissolved in water. The more salts in the solution, the higher the electrical conductivity (EC).

Plant soil salinity tolerances are usually expressed in terms of an 'ECe' value, in decisiemens per metre (dS/m) [eg. see Figure 3, page 17]. For example, at a soil ECe of 18 dS/m barley yields are reduced by 50%. 'ECe' refers to the electrical conductivity of soil water under saturated

ECe = electrical conductivity of a saturated soil paste extract. ECe values are the standard way to display plant soil salinity tolerance data.

EC 1:5 = electrical conductivity of a 1:5 soil/ water mix (by volume).

EC 1:5 values provide a cheap and easy way to estimate ECe's.

conditions.

In scientific jargon, this is the electrical conductivity of a saturated paste extract (which is where the subscript ‘e’ comes from). Strictly speaking, ECe values can only be measured through a laboratory test.

Luckily there’s an easier way to estimate ECe values, by deriving them from ‘EC 1:5’ values. This requires access to a hand-held EC meter and some measuring cylinders (see Table 16).

EC 1:5 values are determined by mixing soil and water (rainwater) in a 1:5 ratio by volume. After mixing and allowing time for settling, the electrical conductivity of the clearer fluid at the top is measured. This value is the EC 1:5.

However ECe values are more useful when looking at plant salinity tolerance information. Values of ECe can be approximated from EC 1:5 values using the following conversions (Table 15).

Table 15. How to convert EC 1:5 values into ECe* values. [ECe* = approx ECe]

Soil type	***Multiply the ‘EC 1:5’ value by this number to estimate ‘ECe’***
Sands	15
Loams	9.5
Clays	6.5

The ECe* values derived from your site can then be compared with charts of relative salinity tolerance information for different species (eg. Figure 3, page 17).

Measuring soil salinity

The process for measuring soil salinity is described in Table 16.

An alternative to doing your own measurements is to send off samples for analysis at a soil testing laboratory. However soil sampling should still be conducted as per the process outlined in Table 16. Salinity testing is routinely performed by laboratories as part of soil nutrient testing.

Mailable soil test kits are available through the ‘South Australian Soil and Plant Analysis Service’ [SASPAS] based at Loxton, or seek guidance from your local agronomist or PIRSA office.

The ‘South Australian Soil and Plant Analysis Service’ and ‘Analytical Crop Management Laboratory’ (SASPAS / ACML) can be contacted on (08) 8595 9125, or see the website for more details: www.ruralsolutions.sa.gov.au/laboratories .

When do I sample?

See Table 16. Mid summer to mid autumn sampling will capture peak salinity levels and indicate site suitability for perennials and/or summer active species. Sampling during the growing season will be required to assess site suitability for winter-active, short-growing season species. Don’t take salinity samples just after rain as this will give misleading results.

Gypsum in soils

Care is required when measuring salinity in soils with natural or applied gypsum (indicated by abnormally high sulphur and low chloride). EC 1:5 and ECe values are inflated as gypsum in the soil dissolves. It is recommended that salinity levels in these soils be determined by a laboratory where appropriate corrections for soluble gypsum can be made.

Table 16. Procedure for DIY measurement of soil salinities.

Step	Action	Comments
Sampling		
• When to sample?	1. Decide on timing of sampling: • <u>'Peak sampling' (mid summer to mid autumn)</u> – is suitable if you are looking to establish any of the major saltland pasture species, eg. saltbush, puccinellia or tall wheat grass. Peak sampling is generally enough to determine the suitability of perennials and/ or summer active species. • <u>To capture seasonal variation.</u> To investigate the suitability of short-growing season (winter-active) species which can avoid high salinities, sampling will need to be undertaken during the growing season.	***'Peak sampling'*** between mid summer to mid autumn (before the opening rains), when salt concentrations are usually peaking, will provide a standardised measure of salinity. However this is only part of the picture. Salinity can vary greatly through the year (see Figure 12). Depending on the local site conditions, salinity can fall dramatically following the break of season, reaching a minimum through winter. Salinities then climb and peak in late summer. ***Knowing how salinity varies*** through the year can reveal opportunities for highly productive, short growing-season legumes.
• Where to sample?	2. Define salinity zones based on the type and presence (or absence) of plant cover. 3. Samples should be collected to represent each major salinity zone. 4. Take 5-10 samples from each zone (to average out the natural variation). Sample down to 10 cm, including the salt crust (where formed). 5. Bulk soil samples from the same salinity zone and mix thoroughly. Use a tube sampler in preference to a spade. **6.** Separate subsoil sampling in the 20-30 cm range, can also be useful**.** 7. Record details: eg. the date and location of soil sampling, and the condition and type of plant cover.	***Areas that look different*** should be treated different. Different salinity zones should be large enough to warrant attention. If sown to a mix of species, these different zones are likely to be colonised by species with different salinity tolerances. ***Topsoil sampling*** is normally sufficient. ***Subsoil sampling*** can be useful if there's been a recent shower of rain (which flushes salts down the profile) or where deep-rooted plants are to be grown. Allow extra soil for determining ***soil textures*** (see below).
Testing		
• Determine soil texture	8. Field test soil textures using a small amount of each sample (to determine whether soils are sands, loams or clays – see Glossary)	***Soil textures*** (sand, loam or clay) need to be known to decide which conversion factor to use in Step 19 (below). Even some lab nutrient analysis tests only report back with EC 1:5 results. Therefore it is recommended that field testing of soil textures is undertaken so that approximate ECe values can be determined.
• Preparing the sample	9. Remove stones, sticks and plant material. Break down the soil clods. 10. Place soil sample on a tray to dry. Alternatively soil can be dried in a	

microwave oven.

11. Thoroughly mix the dry soil sample.

- Measuring EC 1:5

12. Obtain a bottle or small jar with graduated markings and a handheld EC meter.

An old baby bottle may be suitable.

13. Place 100 mL or 20 mL of soil in the bottle. Tap gently to settle the soil.
14. Add rainwater (NOT tapwater) to the soil in the ratio 1:5 by volume. ie:
    - 100 mL soil + 500 mL rainwater, making a total volume of 600 mL, <u>or</u>
    - 20 mL soil + 100 mL rainwater, making a total volume of 120 mL.
15. Place the cap on the bottle and shake for 1 minute.
16. Allow the soil to settle for about another minute.
17. Measure the conductivity of the clearer fluid at the top of the settled mixture using the conductivity meter. This is the EC 1:5 value. Units should be expressed as deci-Siemens per metre (dS/m). Ensure that the meter has been correctly calibrated before use.

Interpretation

- Quick interpret-ation chart

18. Use the following chart to gauge the level of soil salinity (Figure 15). Choose the appropriate soil texture column (sand, loam or clay) and locate the EC 1:5 value in that column.

- Convert to ECe* value

19. Multiply the EC 1:5 value by:
    - 15 for sands,
    - 9.5 for loams, and
    - 6.5 for clays.
20. Compare ECe* values to charts of salinity tolerance (eg. see Figures 2 and 3).

    [ECe* = approx. ECe]

Sands include loamy sands.

Loams include sandy loam, light sandy clay loam & sandy clay loam.

Clays include clay loam to heavy clay.

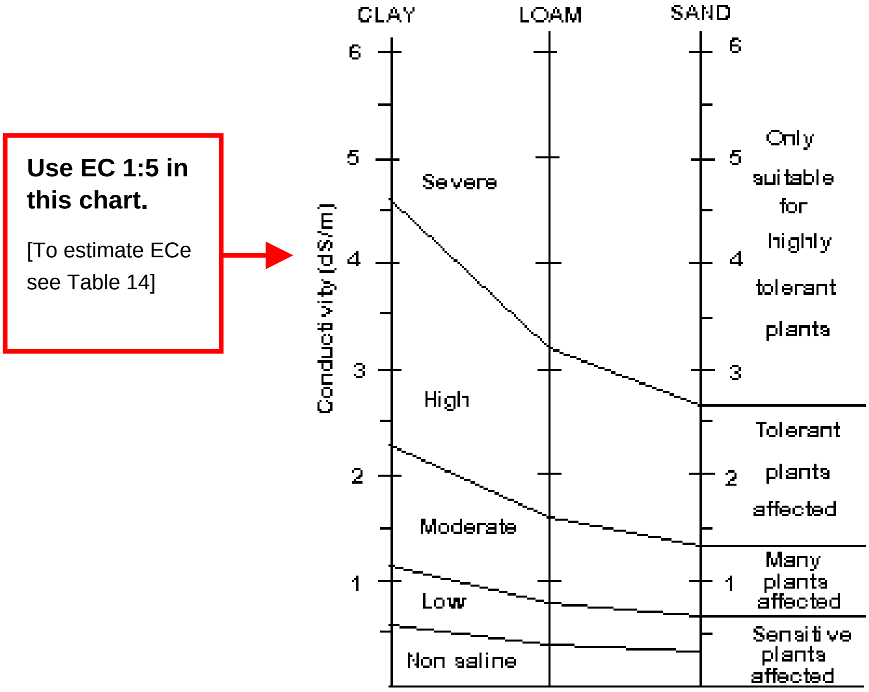


Figure 15. Quick interpretation chart for EC 1:5 values and different soil textures. (Note – the scale on each of the vertical EC 1:5 axes is the same, however the level of salinity impact will vary with soil texture.)

8 EXAMPLES OF SALTLAND & PRODUCTIVE PASTURE OPTIONS

Key points:

- The following examples of saline landscapes are grouped according to salinity levels (as defined in Table 13, page 83).
- They include a quick summary of productive pasture options for each salinity level. (Refer to Sections 3, 5, 6 & 9 for more information on pasture options.)
- This will assist landholders by:
  - providing comparisons to salinity levels on their own property, and
  - raising awareness of potential suitable saltland pastures species.
- More information is required to select suitable pastures (eg. rainfall, pH, soil texture, etc. requirements). Sections 5 & 6 may provide some of this further information on specific plant requirements.

8.1 LOW SALINITY

Class: 1-s (as described by DWLBC, Soil and Land Program).

<u>These areas are not affected by salinity!</u>

Rising ground (sandhill) under perennial pastures. [Tintinara, Coorong Districts, 450-500 mm]

Fractured rock hillslopes, under perennial pastures. [Fleurieu Peninsula, 700+ mm]

Fractured rock hillslopes. [Eastern Mount Lofty Ranges, 500-600 mm]

Upper hillslopes under perennial pastures [Flaxley, Adelaide Hills, 750+ mm]

8.2 MODERATELY LOW SALINITY

Class: 2-s (as described by DWLBC, Soil and Land Program).

Indicators: Sensitive pasture legumes (eg. sub clover) are impacted.

Lucerne starting to be affected is often a good indicator for this salinity level where waterlogging is also present. Because lucerne has a deep taproot it is one of the first plants to shows impacts from saline watertables.

Most plant species will not be affected by moderately low salinity levels, however particularly sensitive species such as sub clovers will show signs of stress. Deep-rooted horticultural species are affected.

Example pasture options [and typical stocking rates]:

- Low rainfall (< 350 mm): Annual and native pastures, saltbush, bluebush, lucerne (without waterlogging) [2-5 DSE/ha/yr].
- Medium rainfall (350-600 mm): Annual and perennial pastures for higher capability saltland (see Section 5.5) [5-15 DSE/ha/yr]
- High rainfall (> 600 mm): Annual and perennial pastures for higher capability saltland (see Section 5.5) [8-17 DSE/ha/yr].

Low rainfall

Lucerne & saltbush on a sandy rise. [Cleve, Eyre Peninsula, 305 mm]

High rainfall

Flat valley floor, in Permian (clayey) sediments. [Delamere, Fleurieu Peninsula, 650-700 mm]

Medium rainfall

Lucerne at risk but currently not affected. [Cummins, Eyre Peninsula, 450-500mm]

Waterlogging prone valley floor (with small saline seeps). [Myponga, Fleurieu Peninsula, 700+ mm]

8.3 MODERATE SALINITY

Class: 3-s (as described by DWLBC, Soil and Land Program).

Indicators: Sensitive crops impacted. Significant yield losses in wheat. Minor yield losses in barley. Sea barley grass can be present. Sub clovers are gone.

If not waterlogged, these areas can still grow useful barley crops.

Only salt-tolerant lucerne varieties will persist here (also without waterlogging).

Example pasture options [and typical stocking rates]:

- Low rainfall (< 350 mm): Annual and native pastures, saltbush, bluebush, salt-tolerant lucerne (without waterlogging) [2-5 DSE/ha/yr].
- Medium rainfall (350-600 mm): Annual and perennial pastures for higher capability saltland (see Section 5.5), tall wheat grass, saltbush [5-15 DSE/ha/yr]
- High rainfall (> 600 mm): Annual and perennial pastures for higher capability saltland (see Section 5.5), tall wheat grass [8-17 DSE/ha/yr].

Low rainfall

Salt-tolerant lucerne stand (foreground only) on rising ground. (The adjacent saltbush is on lower-lying, moderately high to high salinity ground.) [Kimba, Eyre Peninsula, 340 mm]

Saltbush rows with understorey pastures [Snowtown, Mid North, 350-400 mm]

Medium rainfall

Salt-tolerant barley crops adjacent to saltbush [Port Victoria, Yorke Peninsula, 350-400 mm]

Annual ryegrass and medics dominate the understorey between widely spaced saltbush rows. [Ungarra, Eyre Peninsula, 400 mm]

Medium rainfall (continued)

A sensitive lucerne variety beginning to die back. [Tintinara, Coorong Districts. 450-500 mm]

Raised beds on saline, waterlogged land. [Eleanor River catchment, Kangaroo Island, 550-600 mm]

Tall wheat grass pasture. [Mt Charles, Coorong Districts. 450-500 mm]

Lucerne, clovers, medics and volunteer pasture species. [Mt Charles, Coorong Districts. 450-500 mm]

High rainfall

Localised saline seeps with strawberry clover. [Tungkillo, Adelaide Hills, 600 mm]

Poorly draining alluvial flats surrounded by deeply weathered (clayey) sediments. [Western Flat Creek, Adelaide Hills, 750+ mm]

8.4 MODERATELY HIGH SALINITY

Class: 4-s (as described by DWLBC, Soil and Land Program).

Indicators: Unsuitable for wheat. Significant yield losses in barley. Strawberry clover production is diminished. Sea barley grass can be dominant.

This ground is too salty for most field crops and lucerne.

Example pasture options [and typical stocking rates]:

- Low rainfall (< 350 mm): Annual and native pastures, saltbush, bluebush [2-5 DSE/ha/yr].
- Medium rainfall (350-600 mm): Tall wheat grass and puccinellia are highly productive, saltbush, pastures for higher capability saltland – with winter flushing of salts (see Section 5.5) [5-10 DSE/ha/yr]
- High rainfall (> 600 mm): Puccinellia is highly productive. Tall wheat grass is productive unless affected by waterlogging, pastures for higher capability saltland – with winter flushing of salts (see Section 5.5) [5-10 DSE/ha/yr].

Low rainfall

Salt-affected barley crop, on saline creek flats [Tumby Bay, Eyre Peninsula, 340 mm]

Puccinellia with seasonal pasture legumes (barrel medics, clovers), on saline creek flats. [Tumby Bay, Eyre Peninsula, 340 mm]

Medium rainfall

Crop failure. [Kadina, Yorke Peninsula, 390 mm]

Puccinellia with seasonal pasture legumes (burr medic). [Ungarra, Eyre Peninsula, 400 mm]

Medium rainfall (continued)

Dominant cover of sea barley grass with some other grasses and seasonal legumes. [Tintinara, Coorong Districts, 450-500 mm]

Tall wheat grass pasture, with SGSL Producer Network farmers taking pasture cuts. [Kingston, South East, 525 mm]

Sedges and thatching grass with bare ground. [Tintinara, Coorong Districts, 450-500 mm

Tall wheat grass pasture (TWG is the low tussocky plant, not the upright sedge/grass). [Kingston, South East, 525 mm]

Tall wheat grass (green), surrounding puccinellia (light brown) on saline flats. [Murray Lagoon, Kangaroo Island, 550 mm]

High rainfall

Localised saline, waterlogged, acid-sulfate seep. [Fleurieu Peninsula, 600-700 mm] Acid-sulfate seeps require special management (refer to Fitzpatrick et al., 1997).

8.5 HIGH SALINITY

Class: 5-s (as described by DWLBC, Soil and Land Program).

Indicators: Halophytes present (eg. samphire, ice plant). Patchy sea barley grass and scalds. Melaleuca halmaturorum (KI paperbark) can dominate native vegetation in some areas. Tall wheat grass suffers yield losses.

This ground will support productive pastures in the form of saltbush, puccinellia and some tall wheat grass.

Example pasture options [and typical stocking rates]:

- Low rainfall (< 350 mm): saltbush, bluebush [2-5 DSE/ha/yr].
- Medium rainfall (350-600 mm): Tall wheat grass (is now salt affected), puccinellia (is still productive), saltbush [3-8 DSE/ha/yr].
- High rainfall (> 600 mm): Not applicable [High salinities are not likely to be reached in high rainfall areas. Waterlogging will be a bigger problem.]

Low rainfall

Saltbush with volunteer understorey. [Kimba, Eyre Peninsula, 340 mm]

Puccinellia on saline creek flats. [Tumby Bay, Eyre Peninsula, 340 mm]

Medium rainfall

Sea barley grass dominates pasture, with more than 10% bare ground. [Tintinara, Coorong Districts, 450-500 mm]

Samphire and sea barley grass. Productivity from this land in its current state is virtually nil. [Tintinara, Coorong Districts, 450-500 mm]

Medium rainfall (continued)

Sedges and sea barley grass. [Tarlee, Mid North, 450-500 mm]

Puccinnellia established between mounds planted to saltbush, within a regional discharge zone. [Kapinnie, Eyre Peninsula, 450 mm]

Puccinnellia pasture, showing trial spray-topping strips for control of sea barley grass. [Mt Charles, Coorong Districts, 500 mm]

Puccinnellia pasture, with the depth to watertable (<1 m) shown in the clay pit. [Mt Charles, Coorong Districts, 450-500 mm]

Salt-affected tall wheat grass pasture. [Wanilla, Eyre Peninsula, 500-550 mm]

Puccinellia and tall wheat grass pastures on saline flats. [Murray Lagoon, Kangaroo Island, 550 mm]

High rainfall

Not applicable – waterlogging will be a larger issue.

8.6 VERY HIGH TO EXTREME SALINITY

Class: 7-s and 8-s* (as described by DWLBC, Soil and Land Program).

[*Note: there is no class '6-s' as class 6 land is defined as hilly, and generally not associated with salinity.]

Indicators: Halophytes, samphire, *Melaleuca* species including *M. halmaturorum* (KI paperbark), bare scalds. This ground is generally too salty for productive plants. These areas are mostly naturally highly saline ('primary') sites. Where native vegetation remains, these areas are best managed for environmental/ biodiversity values.

Example pasture options [and typical stocking rates]:

- Primary (natural) salinity dominated sites are best managed for environmental values. Native vegetation (including samphire) is protected under the *Native Vegetation Act 1991*.
- A much smaller proportion will be secondary (human-induced) salinity sites. These areas may support saltbush and puccinellia, however the economic value of development will be questionable [1-2 DSE/ha/yr]. Seek guidance.

Low rainfall

Samphire and bare scalds on saline creek flats. [Tumby Bay, Eyre Peninsula, 340 mm]

Salt-affected puccinellia on saline creek flats. [Tumby Bay, Eyre Peninsula, 340 mm]

Medium rainfall

Scalded, eroding land. [Heggaton, Eyre Peninsula, 350-400 mm]

Samphire flat and bare scalded ground. [Diamond Lake catchment, Mid North, 350-400 mm]

Medium rainfall (continued)

Scalded drainage line. [Condowie Plains, Mid North, 350-400 mm]

Scalded land. [Mt Charles area, Coorong District, 500-550 mm]

Bare scalds. [Hopefully not on your place!]

High rainfall

Not applicable – waterlogging will be a larger issue.

9 REGIONAL PROSPECTS & RECOMMENDATIONS FOR SALTLAND PASTURES

Key points:

- Key characteristics of saline sites and plant/ pasture systems, common to the various regions, are summarised.
- Plant/ pasture systems are compared using broad categories of ‘saltland capability’ (refer to Section 4.1).
- The aim of this is to further assist producers to identify the most appropriate saltland pasture systems.

This section outlines the recommended plant-based systems for managing saltland across different regions, using broad categories of ‘saltland capability’.

For South Australia these regions are grouped (due to similarities in conditions and plant systems) as folllows:

- Coorong and Southern Eyre Peninsula,
- Northern Yorke Peninsula, Mid North and northern Eyre Peninsula,
- Upper South East, southern Yorke Peninsula and Kangaroo Island, and
- Adelaide Hills.

For each region, the following considerations are given:

- The broad capability of the saltland for production/ rehabilitation (from high to low).
- Key site characteristics (indicators) to assist producers to identify their category of saltland.
- The recommended plant system likely to be most suited to the category and region.
- A ranking on the plant/ system’s productive potential.
- Brief comments on the system, or the knowledge base associated with it, within the region.

9.1 COORONG & SOUTHERN EYRE PENINSULA

The regions at a glance

The *Coorong* area includes gently undulating land with tracts of sandhills, used mainly for cereal cropping and grazing. Annual rainfall averages 350-450 mm. Salt affected land in this region mostly occurs on broad flats.

Southern Eyre Peninsula (EP) includes coastal flats with 400-500 mm annual rainfall, gently undulating land of the Wanilla Basin (450-550 mm rainfall) and the intervening Koppio Hills where rainfall is up to 550 mm. Most land is used for rotational cropping and grazing (mainly sheep, some beef cattle), except for the steeper slopes of the hills where land use is restricted to permanent pastures. Salt affected land mostly occurs on broad flats or in narrow drainage depressions in the hills.

The prospects for managing saltland

Options and prospects for the major systems found in the regions are shown below, where productive potential refers to best management practice.

Table 17. Capabilities of major saltland pasture systems – Coorong & southern EP.

Saltland Capability	Key Site Characteristics / Indicators	Recommended Plant/ Pasture System	Productive Potential
HIGH	Low to moderate salinity, salinity emerging. Ryegrass, uneconomic for cropping.	• Saltbush + improved under-storey (EP); or • Lucerne (Coorong), With some farmers starting to adopt alternative option in each region.	*Moderate to high* (4-8 t/ha; 8-10 DSE/ha/yr possible with most pasture & animal production in spring/summer).
	Moderate salinity, no inundation, some waterlogging. Sea barley grass Dry salty areas	• Saltbush + improved under-storey; • Balansa clover, tall wheat grass, puccinellia.	*Moderate* (5-6 t/ha when combined with adequate understorey; 6-8 DSE/ha/yr mainly utilised over summer for maintenance).
LOW	Moderate to high salinity, some inundation and waterlogging. Sea barley grass / samphire or patchy scalding.	• Puccinellia, tall wheat grass, balansa clover; • Puccinellia only at higher salinities.	*Moderate* (5-6 t/ha; excellent animal growth in spring/early summer and maintenance in late summer once balansa clover consumed; 6-8 DSE/ha/yr but mainly utilised in spring to early autumn).

9.2 NORTHERN YORKE PENINSULA, MID-NORTH & NORTHERN EYRE PENINSULA

The regions at a glance

Northern Yorke Peninsula (YP) includes gently undulating to undulating land with some sandhills and is in the 350-400 mm annual rainfall zone. Cereal cropping predominates, with grain legumes and pulse crops, and annual medic-based pastures also common. Salinity generally occurs on lower slopes and depressions.

The *Mid-North* is characterized by a series of north-south trending broad valleys floors and intervening ranges. A range of cereal, grain legume and pulse crops are grown, with annual medic or clover-based pastures, depending on soil type. The steeper ranges are non arable. Annual rainfall varies from 400-600 mm. Salinity occurs on lower slopes and drainage depressions in the hills.

Northern Eyre Peninsula includes the Cleve / Mangalo Hills, and a large tract of gently undulating country with sandhills. Annual rainfall is 300-400 mm. Cereal cropping with medic-based annual pastures is the predominant land use. Salt affected land comprises mostly lower slopes and drainage depressions in the hills, and broad depressions and swales on the flatter land.

The prospects for managing saltland

Options and prospects for the major systems found in the regions are shown below, where productive potential refers to best management practice.

Table 18. Capabilities of major saltland pasture systems – northern YP, Mid North & northern EP.

Saltland Capability	Key Site Characteristics / Indicators	Recommended Plant/ Pasture System	Productive Potential
HIGH	Low-moderate salinity. Broad valley floors or interdunal flats. Sea barley grass, salt sensitive species dying, crop failure or low yields.	• Saltbush + sown understorey (e.g. puccinellia, balansa clover, persian clover, burr medic).	*Moderate to high* (4-6 t/ha; 6-8 DSE/ha/yr but mainly utilised over summer/ autumn; isolated cases higher although minimal data available to support these figures); challenging due to lack of livestock in the region.
	Moderate salinity. Broad valley floors or interdunal flats. Sea barley grass	• Saltbush + volunteer species.	*Low to moderate* (3-4 t/ha; 4-6 DSE/ha/yr utilised as maintenance ration over summer/ early autumn); challenging due to lack of livestock in the region.
LOW	Moderate to high salinity. Broad valley floors or interdunal flats. Scalded ground, samphire	Fence off and allow natural regeneration and revegetation (samphire/ native species).	*Nil* (low rainfall) Potential biodiversity asset.

9.3 UPPER SOUTH EAST, SOUTHERN YORKE PENINSULA & KANGAROO ISLAND

The regions at a glance

The *Upper South East* (USE) comprises a series of broad flats, separated by low ranges (old coastal dunes) largely running north west to south east. Annual rainfall is 450-600 mm. The main land use is sheep and beef cattle grazing perennial pastures, with some cropping on better drained land. Salinity occurs primarily on the broad interdunal flats, with generally sand over clay, sand over limestone or clay soils. Landholders often suffer from the twin effects of salinity and inundation. Drainage networks associated with the Upper South East Dryland Salinity & Flood Management Project have alleviated problems in some areas.

Southern Yorke Peninsula (YP) is gently undulating land with 400-500 mm annual rainfall. Cropping (mainly barley and wheat) is the predominant land use, with some grazing of medic-based pastures. Salinity occurs on lower slopes and in depressions.

Kangaroo Island (KI) is characterised by a central plateau and lower lying land in the east. The plateau has undulating topography, and is used mainly for sheep and beef cattle grazing on clover-based pastures. Annual rainfall is 550-800 mm. Salinity occurs along drainage depressions. The undulating land is in the 450-550 mm rainfall zone, where land use is mainly grazing, but with some cropping. Salinity occurs in depressions and broad flats.

The prospects for managing saltland

Options and prospects for the major systems found in the regions are shown below, where productive potential refers to best management practice.

Table 19. Capabilities of major saltland pasture systems – USE, southern YP & KI.

Saltland Capability	Key Site Characteristics / Indicators	Recommended Plant/ Pasture System	Productive Potential
HIGH	Low to moderate summer salinity, some waterlogging with minor inundation. Alkaline pH *Ryegrass, strawberry clover [*If ryegrass/ strawberry clover dominates it may be difficult to establish phalaris due to allelopathic effects.]	• Strawberry clover, chicory, plantain, perennial grasses such as tall fescue, *phalaris, lucerne (non-waterlogged areas).	*High* (8-10 t/ha mainly as spring and summer production; 10-12 DSE/ha/yr possible along with good liveweight gains in spring/ early summer).
	Moderate summer salinity, some waterlogging, no inundation. Alkaline pH Sea barley grass, ryegrass, native clovers.	• Tall wheat grass, strawberry clover, balansa clover, burr medic.	*Moderate-high* (6-8 t/ha including summer growth; 8-10 DSE/ha/yr with grazing possible year-round, but with main production period in late spring/ summer).
	Moderate to high summer salinity, winter inundation but microtopography reduces adverse effects. Alkaline pH Sea barley grass	• Puccinellia, tall wheat grass, balansa clover (in lighter topsoils where there is potential for early winter leaching of salt from the upper profile or on slightly rising ground).	*Moderate* (4-6 t/ha mainly produced in winter/ spring; 6-8 DSE/ha/yr usually grazed early summer or deferred until late summer/ autumn as maintenance ration).

	Moderate to high summer salinity, winter inundation. Alkaline pH Sea barley grass, samphire	• Puccinellia	*Low-moderate* (3-6 t/ha grown in winter/ spring; 5-7 DSE/ha/yr usually grazed early summer or deferred until late summer/ autumn as maintenance ration).
LOW	High summer salinity, low lying basins, inundation for prolonged periods. Scalded, samphire	• Fence off and allow natural regeneration and revegetation (samphire/ native species).	*Low to nil* for grazing Potential biodiversity asset.

9.4 ADELAIDE HILLS

The region at a glance

The *Adelaide Hills* include undulating to steep land, mostly on the eastern side of the Mount Lofty Ranges (MLR), and also incorporating the Fleurieu Peninsula. Land use is mainly cattle (beef with some dairy) and sheep grazing, with very limited cropping (due to steep slopes, rock and wetness). Annual rainfall varies from 400-700 mm. Salt affected land is generally localised and occurs on lower slopes and creek flats. Salinity impacts are reduced in higher rainfall areas, however waterlogging can become a bigger problem.

The prospects for managing saltland

Options and prospects for the major systems found in the region are shown below, where productive potential refers to best management practice.

Table 20. Capabilities of major saltland pasture systems – Adelaide Hills.

Saltland Capability	Key Site Characteristics / Indicators	Recommended Plant/ Pasture System	Productive Potential
HIGH	Low to moderate salinity, waterlogged. Strawberry clover, sea barley grass.	• Phalaris, tall fescues, strawberry clover, persian clover, perennial ryegrass.	*High* (10-12 t/ha including spring/summer growth; 10+ DSE/ha/yr gaining weight over summer); high water tables provide extended growing season, grazing period and therefore productivity.
	Low to moderate salinity. Scalded where erosion has occurred. Sea barley grass	• Tall wheat grass, tall fescues, strawberry clover, burr medic.	*Moderate* (8-10 t/ha; 8-10 DSE/ha/yr with grazing possible year round, but with main production period in late spring/summer).
	High stream salinities with minimal visual land affected due to incised valleys.	• Encourage riparian native vegetation.	*Low to nil* for grazing due to topography.
LOW	Acid-sulphate seepage areas. Spiny rush	• Fence off and allow natural and native revegetation (spiny rush, etc).	*Low to nil* for grazing; stock should be excluded due to very high erosion potential.

10 WEEDS OF SALTLAND PASTURES

Summary points:

- Weed control is essential for successful pasture establishment.
- Major weeds, particularly sea barley grass should be hit twice – once in the spring of the year prior to sowing, and following germination at the break of season.
- Some saltland pastures can become weeds. Care is needed with management and siting.

10.1 CONTROLLING SALTLAND WEEDS

Weed control is essential for the establishment and ongoing management of saltland pastures. It is critical to success, particularly in sea barley grass and curly ryegrass dominant areas.

Effective weed control can be achieved through an integrated approach, combining systematic grazing, nutrition, winter cleaning and spray-topping.

Weeds are opportunistic plants that colonise in pastures where conditions are favourable. Pasture weeds aren't always easily determined as most plants with weedy values have some forage value for livestock at some point in their lifecycle. Examples are annual grasses such as barley grass, brome grass and silver grass, which provide valuable feed over autumn/ winter. In spring these are less desirable due to lower digestibility and the production of damaging grass seeds.

Common weeds that occur on degraded saline land are sea barley grass and curly ryegrass. Adequate nutrition to promote vigorous pasture growth will boost the competitiveness of pastures against weeds, and help to control problem grass seeds, which are a major concern for livestock producers.

Samphire plants (*Halosarcia* spp.) are native halophytic shrubs common to areas with high to extreme salinity and high waterlogging levels. Samphire can be historically established on primary/ natural salinity sites, or recently established on degraded/ secondary salinity sites. Being a native plant, management of samphire is subject to laws under the *Native Vegetation Act 1991*. See the 'Important notes for native vegetation' (Section 6.1.2, page 46) and Section 10.3 for more information.

Establishing new pastures

This usually requires a combination of chemical topping, cultivation, knockdown herbicide and even burning depending on the situation. It is preferable not to leave the soil bare over summer as this will exacerbate soil salinity.

Sites to be sown to saltland pasture need to be sprayed out in the year prior and in the year of pasture establishment. Weeds such as sea barley grass and curly ryegrass are specialists at surviving in saline environments and are extremely competitive with desirable pastures.

Sea barley grass control prior to puccinellia establishment is essential, as this weed can be very competitive in a puccinellia pasture. A spray-top in the spring prior to the year of seeding, and a knockdown herbicide at the break of the season should get on top of the sea barley grass population.

Ensuring adequate phosphorus levels and periodic applications of nitrogen will also increase the competitiveness of the puccinellia pasture sward against weeds.

Trials in the Upper South East looking into herbicide control of sea barley grass in established puccinellia have shown that vacant spaces left after control of sea barley grass were often filled by the less productive salt tolerant weed, curly ryegrass. This highlights the importance of good weed control prior to establishment.

Weed control in mature pastures

The aim of weed control in this scenario is to maximise injury to the weed species, while minimising damage (or causing only recoverable damage) to the main pasture plants.

Chemical spray-topping has achieved significant results in mature stands of puccinellia. A farmer-driven SGSL trial of different herbicides in the Coorong Districts has provided some useful data for the control of sea barley grass and curly ryegrass. Puccinellia appeared damaged initially after the spray-topping but recovered well in following seasons.

In established puccinellia, the best performing spray-top herbicides for sea barley grass and curly ryegrass control were found to be:

- Paraquat (135g/L) and Diquat (115g/L) [Spray Seed ®] at 600mL/ha, and
- Paraquat (250g/L) [Gramoxone ® /Nuquat ®] at *400mL/ha, and *600mL/ha.

*Results indicated a trade-off between the rate (which in turn relates to cost) and the duration of effective weed control, for these top performing herbicides.

In this trial, herbicides were applied from the early tillering (Z23**) to head formation (Z52) and at the median soft dough stage for sea barley grass. [**From the Zadoks or decimal growth scale for cereals, refer to Smith (1998).]

LINK

For further information on this trial refer to:

- The Bunbury SGSL Producer Network Group trial site information ('Weed control in established Puccinellia') via the website: www.landwaterwool.gov.au [copy of 2 page trial site summary on the CD-ROM], or
- The Keith PIRSA Office, ph. (08) 8755 3166.

10.2 THE WEED POTENTIAL OF SALTLAND PASTURES

Some saltland pasture species have potential to be invasive environmental weeds. Hence consideration of weed potential and the likelihood of spreading to adjacent native vegetation areas, and/or aquatic or riparian ecosystems needs to be made when looking at potential establishment sites.

For example:

- Puccinellia has the potential to spread via wind and water, along drainage lines or into adjacent areas with suitable conditions.
- Tall wheat grass can be an aggressive coloniser of both saline and non-saline sites.

Options to prevent saltland pastures becoming a weed problem include:

- Providing buffer zones between saltland pastures and adjacent at-risk areas.
- Not establishing near important at-risk wetlands/ biodiversity/ habitat areas.

- Managing pastures to prevent seed-set (eg. through strategic heavy grazing or slashing for tall wheat grass, see Section 6.4).

Information on the environmental weed risks for a range of species used in dryland salinity management can be found in:

- DWLBC fact sheet # 16 – ***"Environmental weed risks in dryland salinity management"***, available from the website: www.dwlbc.sa.gov.au/publications/fs_brochures.html [copy on CD-ROM].

10.3 THE MAJOR SALTLAND WEED SPECIES

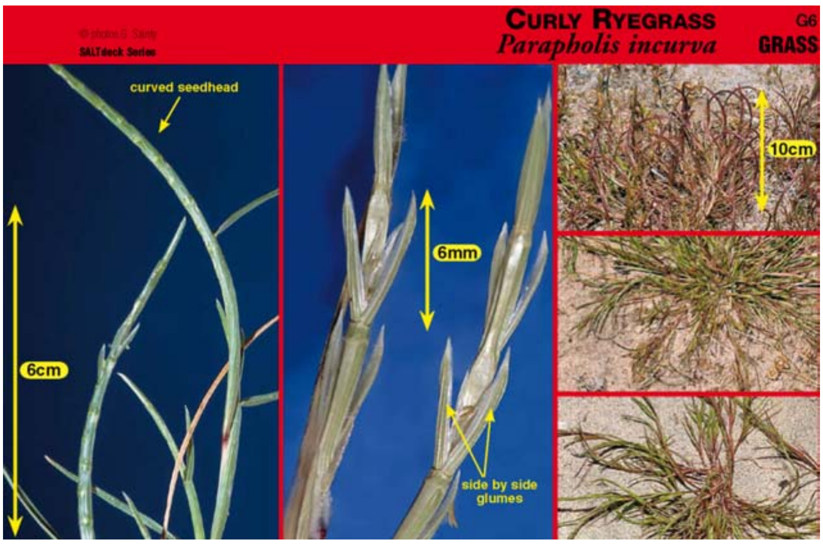
The major weed species encountered in saltland pasture systems are described below.

Sea barley grass (Hordeum marinum)

SALTdeck card series (Anon, 2006)

Sea barley grass (SBG) is an invasive weed of saltland pastures. It is often seen establishing in the gaps in puccinellia pastures during significant dry periods. It is a leafy grass with a distinct flower head, which can be spreading or erect, up to 25cm in height. SBG colonises in low-lying situations associated with pastures on saltland, on a wide range of soil types. It is problematic for wool producers due to its low feed value and contamination of wool with grass seeds.

Curly ryegrass (Parapholis incurva)



SALTdeck card series (Anon, 2006)

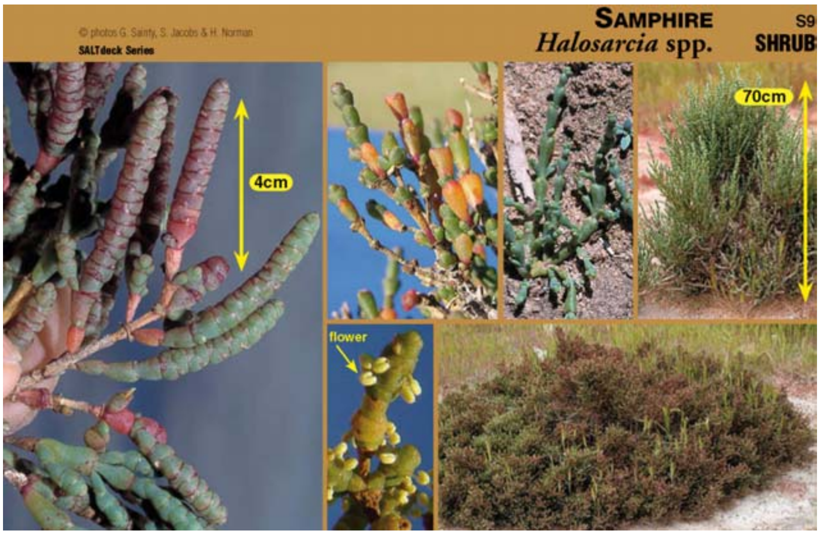
Curly ryegrass (CRG) [also known as coast barb grass] is an invasive, introduced environmental weed with even less productivity than sea barley grass. It is a sprawling tufted grass that is quite thick and curved (hence the name). The leaves can be up to 30cm long, and are rounded, often segmented, pointed and typically curled, with numerous flower heads which produce in spring.

Often found in gaps left by spray-topping sea barley grass in pastures, it is also suited to areas subject to flooding for part of the year. It is an important colonizer of saline depressions and can be abundant in some areas (especially in areas of high winter rainfall. CRG has a short growing period and is suited to a range of soil types.

Samphire (Halosarcia species)

This native species is common on primary (natural) salinity sites (Figure 16a) and can invade secondary saline sites that succumb to high salinity and high waterlogging (Figure 16b).

Management of samphire is subject to the *Native Vegetation Act 1991* (and subsequent amendments). See 'Important notes for native vegetation' (Section 6.1.2, page 46) for more information.



SALTdeck card series (Anon, 2006)

On primary/ natural salinity sites, samphire should be managed for environmental values.

In degraded/ secondary salinity sites, soil salinity testing at the height of summer will provide a guide to whether or not pastures such as puccinellia might be established. The presence of samphire on secondary salinity sites should raise questions as to whether or not saltland pasture development is appropriate, however there is scope at the lower salinity end of its range to successfully establish pastures such as puccinellia.

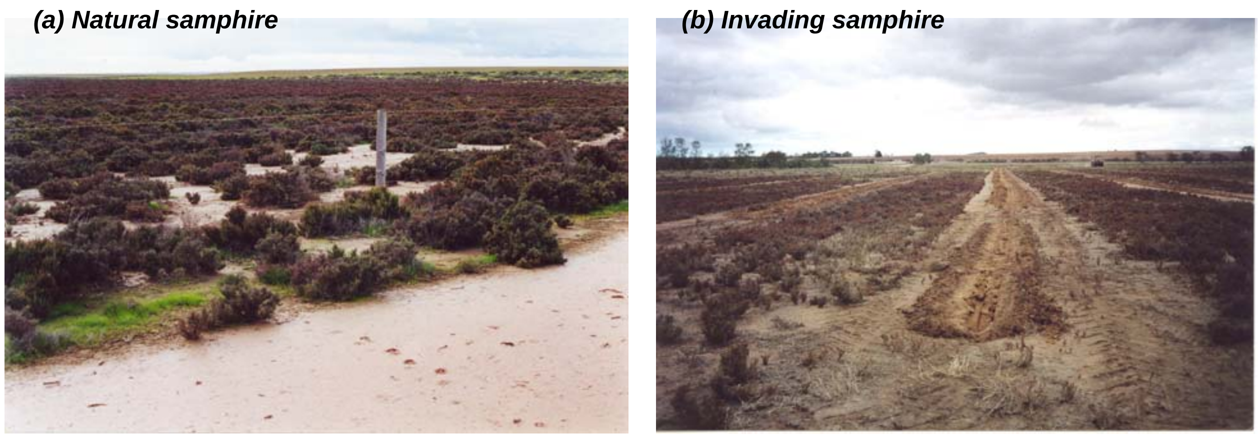
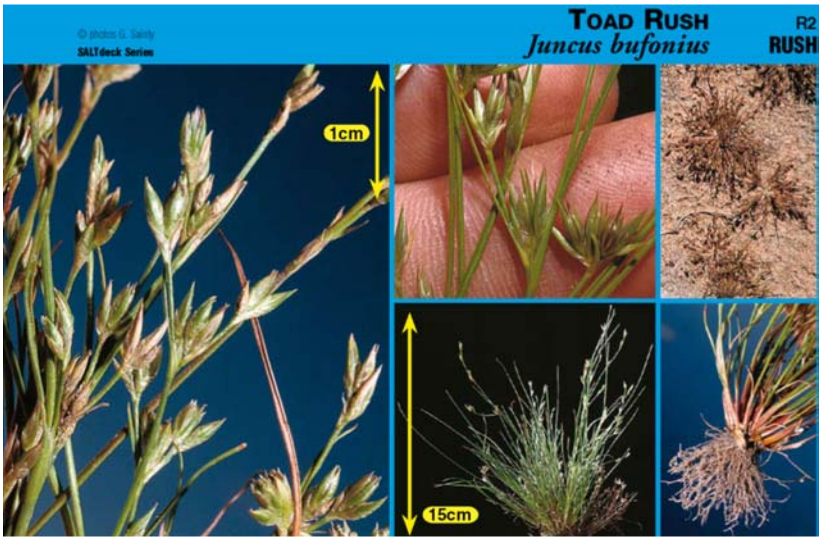


Figure 16. (a) Samphire in a primary/ natural salinity site, and (b) in a degraded / secondary salinity site.

Toad rush
(Juncus bufonius)

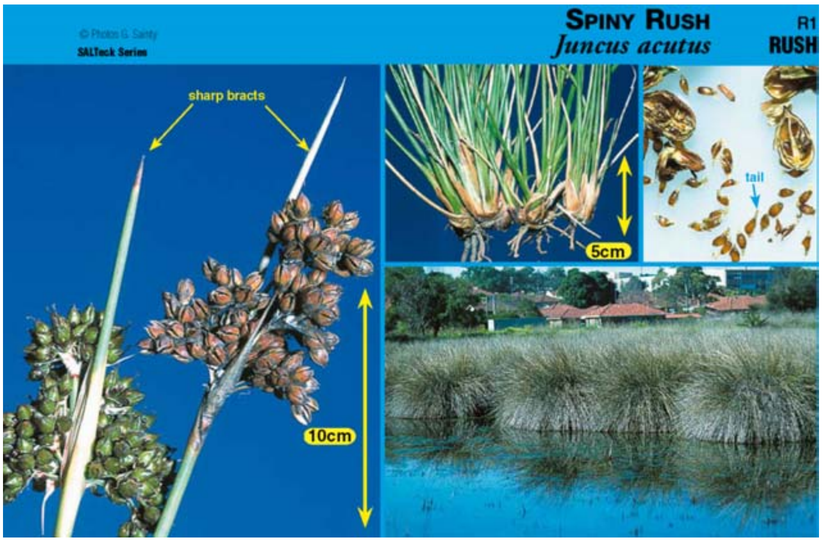


SALTdeck card series (Anon, 2006)

Toad rush is another weed of saltland, though not as common as sea barley grass and curly ryegrass. Tolerant of slightly saline soils particularly where rainfall has leached out topsoil salt, toad rush has a distinct preference for moist soils and is usually found near permanent water or periodic flooding and cold conditions. Toad rush competes well in pastures that have become waterlogged and of low fertility. However it is generally not very competitive in situations with better drainage and fertility. It can tolerate a wide range of soil types from sands to clays.

It is a small narrow-leaved rush, often quite short and grass like in appearance. Leaves are thin, straight and channelled. Plants have lots of stems with flower heads appearing pale to rusty brown in colour. Although short-lived and late germinating, Toad Rush can pave the way for the invasion of low fertility weeds.

Spiny rush
(Juncus acutus)



SALTdeck card series (Anon, 2006)

This native of Europe, Africa and North America, is generally an undesirable weed that excludes other saltland plants. It is only eaten by stock when young and when other more palatable plants are absent.

Mature plants can withstand long periods of inundation and it will thrive in inundated creek lines and freshwater and saline depressions, however it does not colonise very salty areas as seedlings will not tolerate very high salinities in water or soil.

Silver grass (Vulpia fasciculata)

Nie & Saul, 2006

Silver grass

Silver grass is an insidious weed, responsible for large production losses in many areas of South Australia. It affects livestock health, reduces the value of meat and skin, reduces pasture quality and quantity, and reduces crop yields. It is likely that silver grass also contributes to dryland salinity as it is a plant that uses very little water.

Silver grass tends to be less of a problem on saline land as it is not particularly salt tolerant. However silver grass is starting to reappear in salt-tolerant pastures (eg. in the Upper South East) due to a succession of dry years (lowering the watertable) and adjacent to areas that have been drained. Silver grass is beginning to dominate in areas where it hasn't grown previously, reasserting its presence as a weed of agricultural significance.

Silver grass is able to dominate paddocks because they have been overgrazed, are low in fertility, crops and pastures are not competitive, or grass control has not occurred. The plant also has an allelopathic effect, inhibiting the germination of other plants around it. Silver grass produces a lot of seed but the majority is only viable for one or two years. This means that the silver grass seed bank can be easily depleted.

Care should be taken in trying to control weeds such as silver grass in undulating areas. Higher ground needs spray-topping earlier than lower ground, due to differences in available moisture.

LINK

Further information on silver grass control is available from the South East NRM Board, Keith Office, or via the *Saltland Agronomy Information Series Fact Sheet:* ***"Controlling silver grass in lucerne"*** (Morris et al., 2003).

11 ANIMAL ISSUES

Summary points:

- Feed supplementation is required when minimum requirements for metabolisable energy and protein aren't met by saltland pastures.
- The type of stock and feed quality of the particular pasture are important factors in determining supplementation requirements.
- High salt levels in some saltland pastures (particularly saltbush) mean that:
    - Stock will need to limit their intake of salt and hence limit their intake of saltbush. When grazing saltbush, supplementary feeding is also required on the basis of metabolisable energy needs.
    - Stock will need good quality drinking water.
- Nutrient and trace element deficiencies in feed, and in stock, need to be monitored and managed.
- Production will become limited where feed is high in salt, but moderately saline feed can yield production benefits.

11.1 FEED SUPPLEMENTATION

Ruminant animals such as sheep require metabolisable energy (ME) and protein in their diets. For maintenance of liveweight, a mature (50kg) dry sheep requires feed providing around 8-9 megajoules (MJ) of metabolisable energy per day and 7-10% crude protein (CP) [Barrett-Lennard et al., 2003; Holst and White, 2007].

Saltland pastures may require supplementation to balance animal requirements with seasonal or year-round shortfalls in feed quality.

The best (and most cost-effective) form of supplementation will depend on the particular feed quality of the pasture at the time of grazing and the type of stock. Different types of stock will vary in their nutritional requirements (see Table 21). For example, nutritional requirements of lactating or growing stock are higher than normal stock.

Table 21. Minimum energy and protein requirements for sheep from pasture + supplement (Holst and White, 2007).

Class of stock	Minimum nutritional requirements (pasture + supplement)
Dry ewes	9 MJ ME + 9% CP
Lambing and lactating ewes	9 MJ ME + 12% CP
Lambs > 30 kg	9 MJ ME + 13% CP
Weaner lambs	9 MJ ME + 15% CP

[MJ ME = megajoules of metabolisable energy (per kg dry feed), CP = crude protein]

Pastures requiring high levels of ME supplementation should (where possible) be grazed by the class of livestock with the lowest energy and protein demands (eg. wethers, dry ewes and ewe hoggets which are being grazed to maintain their condition only). The best available pastures should be given to weaners, ewes that are being prepared for joining and lactating ewes (Collins, 2006).

Some supplementary feeds are high in energy and protein (eg. lupins, grain, lucerne) while others are lower (eg. cereal hay). Table 22 provides a guide to the nutritional value (ME and CP) of a range of supplementary feeds. Particular requirements should be assessed on a case-by-case basis.

Energy costs (in cents/MJ) should be calculated to determine the most cost effective supplementary feed option.

Table 22. Nutritional values for a range of supplementary feeds (Holst and White, 2007).

Supplementary feed	**Metabolisable energy (MJ/kg dry feed*)** Average *[range]*	**Crude protein (% of dry feed)** Average *[range]*
Hay		
Lucerne	9 *[7-10.5]*	16 *[9-24]*
Clover	9 *[7-10.5]*	14 *[7-20]*
Pasture (mainly clover)	8.5 *[7-10]*	10 *[7-18]*
Pasture (mainly grass)	8 *[6-10]*	7 *[5-14]*
Pasture hay (mature)	7 *[6-8]*	7 *[5-9]*
Cereal hay (oaten)	7.5 *[5.5-9.5]*	6 *[2-9]*
Silage		
Wilted lucerne	8.5 *[6-11]*	17 *[13-20]*
		1st day: dry matter 40-50%
Grains		
Oats	12 *[10-13]*	11 *[5-21]*
Barley	12 *[11.6-13]*	11 *[6-18]*
Wheat	13 *[12-13.5]*	14 *[9-20]*
Triticale	13 *[12-13.3]*	12 *[8-21]*
Lupins	13 *[12-14]*	31 *[27-41]*

*MJ/kg = megajoules of useable energy per kilogram of dry feed.

For more detailed feed budgeting tables (eg. for the dry season and break of season) look into Australian Wool Innovation's "Lifetime Wool" research and extension project, via the website: www.lifetimewool.com.au .

Saltbush

Saltbushes contain high protein but also high salt content (up to 30%). Saltbush also contains insufficient energy (ME) to satisfy maintenance requirements. [However, on low salinity ground Hobbs et al. (2006a) report higher feed quality for saltbush (see page 28). Also lower salt content

(10-15%) is expected for saltbush in low salinity areas (pers. comm. David McKenna, Research Scientist, FloraSearch program).]

Because animals can only consume a limited amount of salt per day, stock grazing saltbush will be forced to limit their intake. This causes them to lose weight, unless saltbush can be mixed with other low salt, higher energy feeds.

This can be achieved through the following strategies:

- ***Understorey pastures.***

  Establishing widely spaced alleys between the saltbush with a sown understorey of annual legumes (clovers, medics) or perennial grasses. With intensive grazing (larger numbers of animals on smaller areas) animals will eat all components of the feed simultaneously.

  This option requires moderately low to moderately affected saltland capable of supporting productive understorey species.

- ***Supplementary hay, grain or stubbles.***

  In denser stands of saltbush, low salt high energy feed is provided by supplementation with hay, grain or crop stubbles.

  This option is suited to moderately high to highly affected saltland.

- ***Where saltland is immediately adjacent to productive pastures.***

  For example, stock may be rotated between saltland pastures and a quality dry feed or lucerne paddock on adjacent rising ground.

The main requirement of any supplement to saltbush is that it has low salt levels (<10%) and metabolisable energy (ME) content greater than 9 MJ/kg dry matter. It is important that any hay or silage to be used is tested. If the ME is not greater than 9 MJ/kg then it is of no extra benefit than the saltbush itself (Collins, 2006). In addition, any supplement provided to sheep on saltbush needs to have a dry matter digestibility of over 60%.

Puccinellia

Puccinellia is winter-active and shoots vigorously after the opening rains of autumn. The highest feed values (CP levels of 15-25%, digestibility 60-75% and ME 10.5-11.5 MJ/kg dry matter) are associated with green leaves over winter and early spring (June –October). Nutritive values decline as the plants flower (in September) and mature (hay-off in December) [CP < 5%, digestibility < 50% and ME 5.5 - 7MJ/kg dry matter]. The plant remains dormant over summer. (Barrett-Lennard et al., 2003; Morris, 2001; Smallcombe, 2004)

Despite the decline in nutritive value, some green stems remain over summer and it remains palatable at all stages including when it has hayed off. The salt content of puccinellia is negligible.

Morris (2001) provides some indication of seasonal variations in the feed quality of Puccinellia, from data gathered over 2 years on properties in the Upper South East (see Figure 17).

Condition scoring of animals grazing puccinellia on a regular basis will indicate when supplements are required.

As previously mentioned, energy and protein requirements for different classes of stock (Table 21), feed quality for different types of supplements (as indicated in Table 22), and feed quality of the particular pasture (determined by testing) are important factors in selecting appropriate supplementary feed.

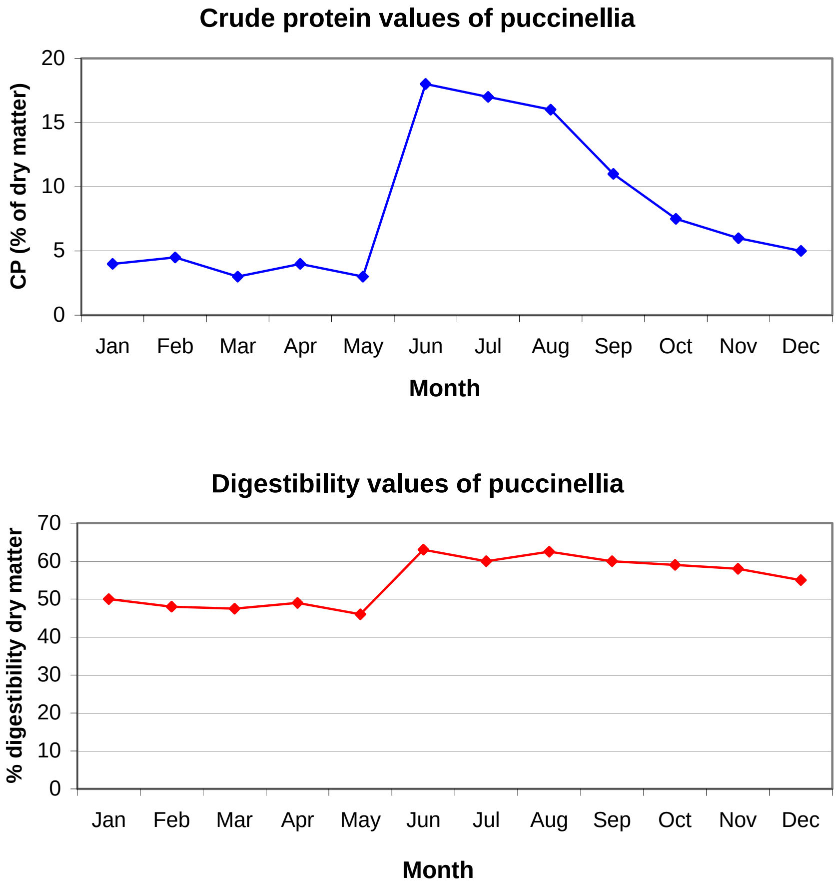


Figure 17. Seasonal variation in crude protein and digestibility values for puccinellia (from Morris, 2001).

Tall wheat grass

For tall wheat grass, pasture height is a major determinant of feed quality (Borg and Fairbairn, 2003) [see Table 11, page 73]. Pastures kept grazed below 20cm are high quality pastures providing equal feed value to phalaris or annual ryegrass pastures in winter, and greater in summer when phalaris and annual ryegrass have hayed off.

TWG is summer active with most growth occurring from late spring onwards. It sets seed from January to March and this corresponds with a decline in feed quality over late summer. Grazing to avoid poor quality mature stems at this time will minimise feed quality losses (rank pasture), however some decline will occur even when pastures are kept short. Despite this decline in quality it is often the only green feed available at this time and still valuable when compared to costly supplementary feed.

Condition scoring of animals on a regular basis will indicate when supplements are required.

As previously mentioned, energy and protein requirements for different classes of stock (Table 21), feed quality for different types of supplements (as indicated in Table 22), and feed quality of the particular pasture (determined by testing) are important factors in selecting appropriate supplementary feed.

11.2 IMPACTS OF SALTY DIETS

Feeding rates

Levels of feed intake for stock grazing saltland pastures will depend on the interaction between salt levels and feed quality. Sheep can tolerate a salt (sodium chloride, NaCl) intake of about 100-150 grams per head per day, provided there is a good supply of fresh drinking water (Kelly, 2002; Masters et al., 2006). However their tolerance to salt intake in their diet reduces with poorer quality feed (see Figure 18). This influence on feed intake is likely to vary as salt intake and pasture feed quality vary, across the landscape and across the seasons.

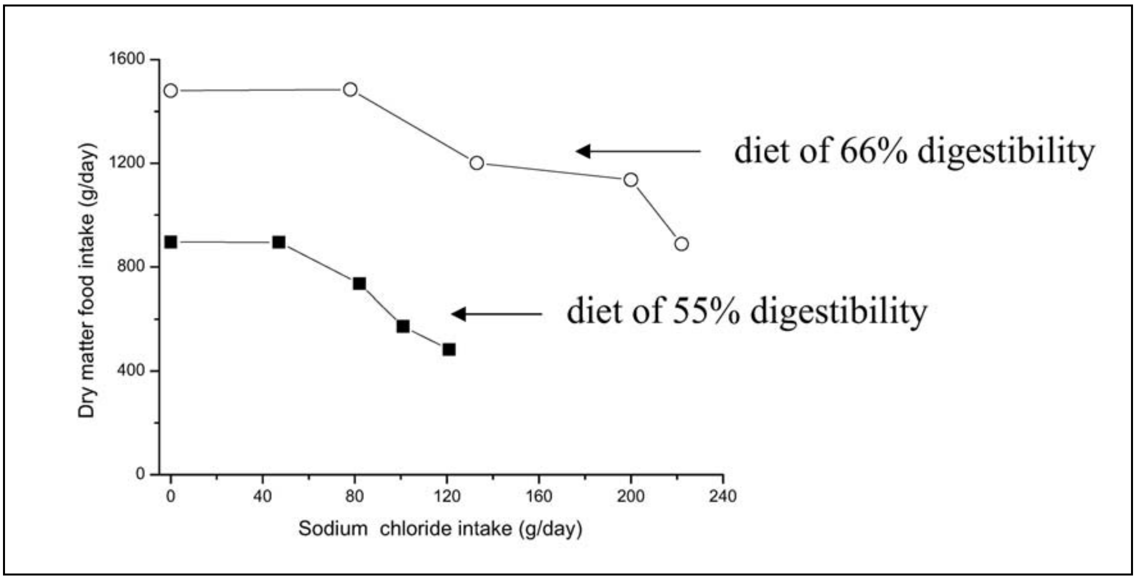


Figure 18. Effect of diet quality and salt content on dry matter intake by Merino wethers. As feed quality drops (ie. lower digestibility) feed intake rates are already lower (than for higher quality feed), and further decline in feed intake rates occur sooner with increasing salt intake. (Kelly [2002], from data published by Wilson [1966])

Recent research and reviews (Masters et al., 2006), conducted through the CRC Salinity by Professor Martin Sillence (Charles Sturt University) and Dr David Masters (CSIRO Livestock Industries), reported in ***"Focus on salt"*** (CRC Salinity, 2006) indicate that:

- Both sheep and cattle can manage diets containing up to 8.5% salt with no detrimental effect on liveweight gain.
- Intake rates, digestibility of feed and livestock growth are all depressed when dietary salt is higher than 10-12%.
- When dietary salt reaches 20%, feed intake is suppressed by 55% in both sheep and cattle, restricting the growth of both animals.
- Saltbush may contain up to 30% salt, indicating the need for supplementation with low salt feed.
- Where high and low salt feeds are available together, stock will select a mixed diet with a lower salt level that optimises the overall feeding value.
- Salt does not appear to be a barrier to diet selection, excepting that it will restrict intake at high levels.

Further research findings (Franklin-McEvoy, 2007) on the impacts to stock from grazing saltbush and the influence of unpalatable saltbush are discussed in Section 6.2.5, page 61.

Foetal development in lambs

Research has shown that lambs born to mothers that had a high salt load during pregnancy preferred slightly saltier food, consumed less water after ingesting salt, and had a different blood concentration of the hormone that controls salt balance, compared with lambs from mothers on a regular low salt diet (Masters et al., 2006).

Increased water intake, liveweights & meat quality

Where stock grazing on saltland pastures show liveweight gains, this may be due to increased water intake rather than improving condition (Barrett-Lennard et al., 2003). [In this context, condition (fat) scores rather than liveweight gains would provide a less ambiguous measure of stock improvements.]

However there is an upside to increased water intake, as a study has shown that this could reduce dehydration in livestock before slaughter (Pearce et al., 2004). This would tend to reduce carcass shrinkage and improve returns to abattoir processors and farmers. There is also evidence for beneficial changes in carcass composition arising from the ingestion of salt, with higher protein, less fat and a higher proportion of unsaturated fats (Kelly, 2002; Walker et al., 1971).

11.3 OTHER NUTRITION ISSUES

Vitamin E benefits

Saltbush feed can help sheep overcome Vitamin E deficiency sometimes associated with dry feed (Pearce et al., 2005). Symptoms of Vitamin E deficiency include a muscle wasting condition known as nutritional myopathy. Costly Vitamin E supplements are available to protect sheep against this disease. However grazing of saltbush in summer can cause a 3-fold increase in Vitamin E concentrations in meat. Increased Vitamin E in the meat will also increase the storage life of the meat on supermarket shelves.

Nutrient and trace element deficiencies

Like any type of stock feed, saltland pastures may be prone to deficiencies in major nutrients or trace elements. Whether this translates into a problem for stock will depend on the level of deficiencies in the feed, the duration stock are grazing it and whether or not deficiencies can be identified and managed.

Major mineral/ nutrient deficiencies become evident through a range of clinical signs (see Table 23), however the larger problem in practice is recognition of sub-clinical deficiencies. Such deficiencies can be transient and reduce animal production without any specific signs. Body stores of nutrients can sustain stock through periods of dietary inadequacy, however this is not always the case (for example with magnesium in lactating animals) [Standing Committee on Agriculture (SCA), 1990].

Blood testing animals and feed analysis are the best way to identify sub-clinical deficiencies. Guidelines for desirable mineral concentrations (requirements and tolerances) in livestock feed, and critical concentrations for the growth of selected pasture species are summarised in Judson and McFarlane (1998).

A Vitamin B_{12} deficiency in livestock grazing saltland pastures was identified in a producer-initiated SGSL trial in the Mt Charles district of the Upper South East (refer to link below). This work also identified a decline in feed quality in puccinellia over summer-autumn, resulting in less than desirable mineral concentrations, including the major nutrients phosphorus (P), calcium (Ca), magnesium (Mg) and trace elements copper (Cu) and zinc (Zn). This may or may not present a problem, depending on mineral levels persisting in stock and the use of supplementary feed.

Further information on this trial can be obtained from:

- The Saltland PPP SGSL Producer Network Group trial site information (‘The nutritional requirements for livestock production grazing saltland pastures’) via the website: www.landwaterwool.gov.au [copy of 2 page trial site summary on CD-ROM], or
- The Keith PIRSA / Rural Solutions SA office, ph. (08) 8755 3166.

Table 23. Typical signs of mineral disorders in grazing livestock (in Judson and McFarlane, 1998) that may be of relevance on saltland pastures.

Element	Marginal [A]	Severe	Potential underlying causes
Calcium	Reduced growth Reduced milk production	Lameness and stiffness of gait Enlarged Joints Irregular teeth in lambs Milk fever characterised by muscle tremor, ataxia and collapse	Livestock fed high grain diet Increased demands in lactation
Magnesium	Reduced feed intake Loss in condition Reduced milk production	Grass tetany characterised by increased irritability, convulsions and death	Old cows in early lactation most susceptible Green grass-dominant pasture High potassium levels
Phosphorus	Reduced feed intake Reduced growth Reduced fertility	Abnormal appetite Softening of bones, lameness and bone fractures, Reproductive problems	Cattle more susceptible than sheep Low soil phosphorus Dry mature pasture
Sulfur	Reduced feed intake Reduced wool growth	Reduced feed intake Loss of condition	Low sulphur soils Dry pasture
Cobalt	Depressed appetite Reduced growth, unthriftiness Reduced wool growth	Loss of appetite Watery discharge from eyes Anaemia Reduced fertility Rough and faded coats White Liver Disease	Sheep are more susceptible than cattle Coastal calcareous sands, soils of high manganese oxide content Lush grass-dominant grasses
Copper	Depressed growth (cattle) Reduced wool growth Depigmentation of wool and hair	Steely wool and rough coats Swayback in lambs characterised by uncoordinated hindquarters Scouring in cattle Bone fragility, anaemia, Reduced fertility	Soils low in copper, waterlogged or high in molybdenum. Grass-dominant green pasture Pastures high in iron, sulphur or molybdenum.
Selenium	Reduced wool growth Reduced growth Subclinical mastitis in dairy cows Diarrhoea	White muscle disease characterised by bilaterally symmetrical lesions in skeletal muscle, lesions in heart Increased mortality Infertility in ewes	Sheep are more susceptible than cattle Soils of low pH, waterlogged Areas of >500mm annual rainfall Clover dominant pastures
Zinc	Reduced growth rate Reduced reproductive rate	Reduced feed intake Reduced wool growth and loss of crimp Rough coats Dry and Cracked skin	Soils low in Zinc Dry mature pasture

[A] Marginal signs may also be seen during severe deficiency.

11.4 SHEEP VERSUS CATTLE?

Research conducted through the CRC Salinity (Masters et al., 2006) indicates that sheep do not outperform cattle on diets that contain up to 20% salt, as both animals experience similar restrictions to feed intake (see Section 11.2 'Impacts of salty diets – feeding rates').

According to this work, cattle appeared to have a greater ability to digest poor quality feed and show relative immunity from the effects of a high salt load on the digestive process.

In addition, cattle may be particularly suited to grazing of tall wheat grass pastures which have the potential to grow tall and rank.

On the other hand, sheep grazing on salty feed (eg. saltbush) appear to be able to pass down an increased tolerance of salty feed to their lambs.

This information may encourage cattle producers to make more use of saline land, while observations that pregnant ewes can be fed a reasonably high salt diet without adverse effects on the ewe or developing foetus will be useful knowledge for sheep producers.

Anecdotally, graziers in the Upper South East have been able to increase nominal stocking rates (DSE/ha/yr) by grazing cattle, in comparison to sheep. Some producers have also found cattle to be less selective grazers and less likely to destroy grass cover by grazing too low.

11.5 DRINKING WATER

Salinity of drinking water

Animals grazing salty fodder (particularly saltbush) wash the salt through their bodies by drinking a lot of water, which needs to be as fresh as possible. [In contrast, puccinellia has a relatively low salt content.] Table 24 provides a guide to recommended salinity levels for stock water (sheep and cattle) when not consuming a salty diet. Salinities should be lower when grazing saltland pastures, and a maximum level of 5 dS/m (3,200 ppm) is suggested.

Table 24. Guide to salinity tolerances for sheep and cattle. (Salinities should be less than this if consuming a salty diet.)

Animal	Maximum concentration for healthy growth	Maximum concentration to maintain condition	Maximum concentration tolerated
Sheep	9 dS/m (ECw) or 6,000 ppm (TDS)	20 dS/m (ECw), or 13,000ppm (TDS)	22 dS/m (ECw), or 14,000 ppm (TDS)
Beef cattle	6 dS/m (ECw), or 4,000 ppm (TDS)	8 dS/m (ECw), or 5,000 ppm (TDS)	16 dS/m (ECw), or 10,000 ppm (TDS)

Consumption rates

The Standing Committee on Agriculture (SCA) [1990] provides some examples of annual water use for sheep, as shown in Table 25. When grazing on saltbush, sheep can consume 2-3 times the normal amount of water.

Table 25. Example annual water use for sheep (SCA, 1990).

Location and average annual rainfall	Diet	Sheep liveweight (kg)	Annual consumption (L/year)
Hay, NSW (350 mm)	*Atriplex vesicara* (semi-arid 'Bladder Saltbush') with grass, - in a good season	35	600
Hay, NSW (350 mm)	*Atriplex vesicara* (semi-arid 'Bladder Saltbush') without grass, - in drought	45	2000
Deniliquin, NSW (405 mm)	*Danthonia* grassland	50	400
Ivanhoe, NSW (302 mm)	*Stipa variabilis* (grass) & Bassia spp. (shrub)	60	500

Therefore, estimated guideline figures for annual water consumption rates (per DSE) for different scenarios are:

- 400-500 L/year when grazing on low to moderate salt-tolerant grasses/ legumes;
- 500-1000 L/year when grazing on mixed saltbush and grass pastures;
- 1000-1500 L/year when grazing on saltbush in moderate rainfall areas;
- 1500-1800 L/year when grazing on saltbush in low rainfall areas (< 350 mm); and
- 1800-2200 L/year grazing on saltbush, during drought conditions.

12 TOOLS FOR ESTIMATING PROFITABILITY

Summary points:

- Economic tools have been developed to help in the assessment of saltland pasture establishment and management. These are:
    - A 'profitability calculator' for evaluating the profitability of establishing a saltland pasture system under different economic scenarios.
    - Pasture response to fertiliser calculator – which determines the response in established pastures necessary to recoup fertiliser expenses.

12.1 THE 'PROFITABILITY CALCULATOR' FOR SALTLAND PASTURE ESTABLISHMENT

The profitability calculator is a sensitivity analysis model for evaluating the profitability of saltland pasture establishment (developed by PIRSA Senior Economist Graham Trengove). This model considers a range of factors to determine levels of profitability for different scenarios.

The economic measures of performance used by the model are:

- Net present value (10%) [NPV (10%)] – this is the total future profit generated from pasture development over the life of the pasture, in today's dollars (assuming a 10% discounting rate).
- Internal rate of return (IRR) – this is the interest rate you could borrow money at and just break even.
- Minimum pasture life – the life of the pasture required to break even. Beyond this time, profits are made.

This model assesses the value of developing the saltland itself, concentrating on the direct cash flow benefits of increased stocking rates. It does not consider some of the additional benefits that are seen in the context of the whole farm operation (as discussed in Section 2.1 'Selling points for saltland pastures'). These additional benefits can include more productive paddock use in non-saline parts of the farm, decreased supplementary feed requirements, weed control benefits and increased land value.

A particular development scenario is considered a positive investment where:

- the NPV (10%) is greater than zero, AND
- IRR is greater than 10% (ie. exceeds current interest rates), AND
- the minimum pasture life required to break even is well within expectations.

According to the model, the greater the NPV and IRR across the life of the pasture, the more worthwhile the development is in economic terms. However, the risk of failing to meet expectations must also be weighed up.

TOOL

The 'profitability calculator' is available in Excel ® format on the CD-ROM enclosed with this manual. Figure 19 shows a graphic of the spreadsheet format.

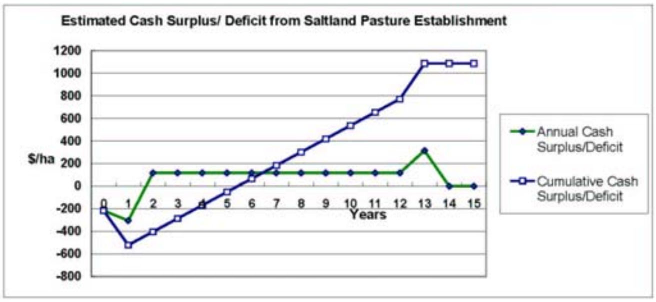
A Sensitivity Analysis to evaluate the profitability of saltland pasture establishment

Insert your figures in the coloured cells in column "G" to evaluate your own investment

The model is based on per hectares costs and returns

Vary your figures to test the sensitivity of the assumptions on the final outcome.

1 Pasture establishment costs		
Cultivation	20	$/ha
Seed	88	$/ha
Fertiliser	38	$/ha
Weed & Pest control	20	$/ha
2 Other Capital costs		
Fencing	25	$/ha
Water	25	$/ha
3 Grazing foregone during pasture establishment		
Grazing before renovation	1.5	dse/ha/yr
Months grazing foregone	12	months
4 Annual Pasture Costs after renovation		
Fertiliser	20	$/ha
Weed & Pest control		$/ha
Other		$/ha
5 Capital value of extra Livestock *	45	$/dse
6 Estimated carrying capacity of renovated pasture (Average over life of the pasture)	7	dse's
7 Estimated life of pasture (15 year maximum)	12	years
8 Profitability of livestock	25	Gross margin/dse



RESULT

NPV(10%)	$265	The value of investment in todays dollars
IRR	19.2%	The interest rate at which the investment breaks even

* The model assumes that livestock numbers are increased to utilize the extra feed produced from the pasture. The extra livestock may be either purchased or retained from stock that might otherwise have been sold. The cost of the extra livestock is included in the budget to evaluate the profitability of the project.
At the end of the project it is assumed the extra livestock are sold and the proceeds are also include in the budget.
The capital value of livestock and the Gross margin/dse will vary depending on the type of livestock enterprise being run on the pasture (e.g merinos, prime lambs or beef).
Examples of livestock Gross Margins can be obtained from the annual, "Farm Gross Margin Guide", published by Rural Solutions SA.

Estimated Cash Flow (per hectare)

Year	0 (Start up)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pasture Establishment	166															
Other Capital Costs	50															
Grazing Foregone		38														
Annual Pasture Costs		20	20	20	20	20	20	20	20	20	20	20	20	0	0	0
Extra Capital invested in Livestock		247.5														
Gross Margin from extra Livestock			137.5	137.5	137.5	137.5	137.5	137.5	137.5	137.5	137.5	137.5	137.5	0	0	0
Value of extra livestock at end of pasture life		0	0	0	0	0	0	0	0	0	0	0	0	315	0	0
Annual Cash Surplus/Deficit	-216	-305	118	118	118	118	118	118	118	118	118	118	118	315	0	0
Cumulative Cash Surplus/Deficit	-216	-521	-404	-286	-169	-51	67	184	302	419	537	654	772	1087	1087	1087

Model prepared by Graham Trengove (PIRSA), April 2007

Figure 19. Graphic of the 'Profitability Calculator' in Excel ® spreadsheet format.

A range of factors will influence the profitability of particular systems. These factors are discussed below.

Costs

Likely costs associated with establishing and maintaining saltland pasture systems include:

- Drainage works, which in some cases may be a pre-requisite to achieving successful establishment. This would include surface and groundwater drains, and raised bed formation.
- Fencing, to allow appropriate grazing management and pasture establishment.
- Pasture establishment costs, including cultivation, seed, fertiliser, weed and pest control.
- Pasture maintenance costs, including fertiliser and weed and pest control. (The profitability calculator model assumes that maintenance costs prior to saltland pasture development are zero.)
- Water point establishment (including poly pipe and troughs).
- Annual water costs, associated with livestock water consumption.

- Capital invested in additional livestock (to take advantage of higher production).

Capital / infrastructure costs

Total capital / infrastructure (eg. fencing, water points, etc) establishment costs per hectare will vary considerably depending on the hectares being renovated, whether the area is already fenced off, and the proximity of the site to existing water supplies.

Stocking rates

Where greater numbers of stock can be adequately supported, greater economic benefit will be obtained by buying more stock to utilise available feed, rather than just having more feed for existing stock.

Stocking rates on previously 'low value' saline land can be substantially improved. However, consideration of land class and appropriate farming systems for that land, should be foremost when looking at potential sites for saltland pasture development.

Low salinity land may be capable of supporting more traditional cropping activities (eg. more salt tolerant species such as barley), or higher production low to moderate salt-tolerant pasture species.

Moderate to high salinity land (where sea barley grass, some samphire and other salt tolerant species are often present) will be the best bet for establishing profitable saltland pastures (eg. puccinellia, tall wheat grass and saltbush).

Very high to extreme salinity land (typically bare scalds with some samphire) will struggle to support profitable grazing activities. Usually this land is naturally highly saline and is best managed for environmental values where possible.

Capital invested in additional livestock

The start-up cost of purchasing DSEs will vary with livestock types and market forces. This cost can also be considered as the income foregone when stock are retained (not sold off) due to extra available feed.

Gross margins

Annual gross margins will depend on the particular livestock enterprise (eg. self-replacing Merino flock, prime lambs, cattle). Examples of livestock gross margins can be obtained from the annual, "Farm Gross Margin Guide," published by Rural Solutions SA.

LINK

Copies of the ***"Farm Gross Margin Guide"***, published annually by Rural Solutions SA can be obtained from the Roseworthy Information Centre, Freecall: 1800 356 446, Fax: (08) 8303 7629, Email: farmer.info@saugov.sa.gov.au , or Online bookshop: www.ruralsolutions.sa.gov.au/bookshop.

Water costs

At establishment, costs will include infrastructure such as troughs and pipes. For ongoing management the cost of water supply needs to be considered. Animals grazing saline pastures require good quality drinking water, and required intakes will rise with increasing salt in the diet (see Section 11.5). Currently in South Australia, mains water for primary production follows a two-tiered pricing system: 47 c/kL up to 125 kL/year, and $1.09/kL thereafter (SA Water). Therefore water costs will depend on the composition of saltland pasture in the total diet (which drives water consumption levels) as well as water use across the rest of the property.

Pasture life

Pasture life will vary between species and with site conditions. The longer a pasture lasts, the less often establishment costs will need to be outlaid. Anecdotal evidence from growers suggests that puccinellia, saltbush and tall wheat grass pastures can exceed 25 years in age with appropriate management.

For low-moderate salt-tolerant pasture legumes and grasses (eg. clovers, medics), these species will reseed and their persistence will depend on how long suitable conditions can be maintained. Of course renovation or pasture improvement will be required from time to time.

12.2 PASTURE RESPONSE TO FERTILISER CALCULATOR

Pastures will often respond to the application of fertiliser, but how do we know if the benefits outweigh the costs? Pastures may be held back by poor soil conditions (eg. pH, sodicity, boron, waterlogging, etc.), lack of moisture, low soil temperatures and/or shallow soil depth. Optimum fertiliser rates may provide net positive returns in terms of extra value in feed. But how can we determine this?

The following is a simple calculator to determine the pasture response in established pasture necessary to recoup fertiliser expenses (provided by PIRSA Senior Economist Graham Trengove).

Fertiliser rates can be adjusted if pastures are not meeting the required response rates, as this would indicate that there is some wastage (and extra expense) associated with surplus fertiliser that is not providing value for money.

TOOL

Pasture response to fertiliser calculator

1. Determine the cost of proposed fertiliser application (including freight and spreading costs).

   e.g. 50 kg/ha urea @ $515/tonne = $25.75/ha

2. Determine the minimum return you require from the fertiliser investment to cover initial cost, risk, interest and uncertainty.

   eg. 25% above cost (ie. 125% of initial outlay)

3. Determine the pasture requirement per DSE.

   eg. Dry matter consumption per DSE (330 kg)/pasture utilisation rate (40%)

   = 825 kg

4. Determine the likely return (annual gross margin) from the livestock enterprise.

   eg. $25/DSE

5. Divide gross margin per DSE by pasture requirement per DSE.

   eg. $25/ 825 = 3. 03 cents/kg

6. Multiply fertiliser cost (cents/ha) by the rate of return and divide by figure arrived at in Step 5.

   [2575 x (125%)]/ 3.03 = [2575 x 1.25]/3.03

   = 1062 kg/ha (Required increase in dry matter production, in response to fertiliser)

For this example you need just over a tonne increase in dry matter per hectare to make a return of 25% above cost on the $25.75/ha spent on urea, assuming a 40% pasture utilisation rate and a gross margin of $25/DSE. A higher gross margin or higher pasture utilisation rate will reduce the amount of dry matter increase necessary to make a profitable return on the fertiliser application.

If saltland pasture is being utilised to its full extent (> 90%) over autumn and early winter this can offset the cost of supplementary hay and grain.

Discussion

Responses to fertiliser treatments can be highly variable between sites and between seasons (also see Section 6.1.5, page 51). This suggests that a standard practice of regular fertiliser applications on salt-affected pastures, to produce extra dry matter to be grazed by livestock, is not as a rule always going to be profitable.

To improve the likelihood of fertiliser applications being profitable, consideration needs to be given to the circumstances that are likely to contribute to profitability:

- ***Conduct soil tests to better assess the probability of obtaining a good response.*** Only apply fertiliser if a good response is likely and to paddocks / soils where the best response is most probable. Adequate phosphorus levels are required to maximise responses to applied nitrogen. Grass will generally respond to nitrogen given adequate moisture and temperature, but additional nitrogen may not be required where legumes are present.
- ***Assess seasonal conditions, feed supply and timing of opening rains.*** Apply fertiliser if you need the extra feed and fertiliser can be applied early enough to get a good response before it gets too cold or too wet.
- ***Assess existing feed supply and the cost of alternatives.*** How does fertiliser application and the cost of extra feed produced compare with conserving hay or purchasing feed?
- ***Assess the profitability of livestock enterprises.*** Fertiliser applications are most likely to be profitable when livestock returns are high. If feed is scarce, you need to make an assessment about whether it is better to grow more feed, buy feed or sell livestock. What we do know is that applying fertiliser to produce extra feed in late spring to feed wethers for wool production is not likely to be profitable.
- ***Assess alternative investments.*** If you are trying to maximise income you should take on investments in declining order of profitability. Money should only be spent on fertiliser if all of the more profitable things to do have been done and there is still spare cash to invest in fertiliser.

Important!

This is not to suggest that short-term profit taking should be the driver for managing saltland pastures (or any land for that matter). Good management (including appropriate fertiliser use) will build resilience into saltland pastures, limit weed growth and potential and make them more dependable. In contrast, saltland pastures can be easily degraded by poor or undisciplined management practices (eg. overgrazing or baring soil in summer). Long term sustainability should be the ultimate goal.

13 CASE STUDIES

Summary points:

- A number of case studies outlining producer's experiences with saltland pastures is contained on the attached CD-ROM.
- These include example economic analyses for saltland pasture development.

Case studies for the following producers (see Figure 20 for locations) can be found on the attached CD-ROM:

1. Geoff Kroemer (Tumby Bay, Eyre Peninsula) – puccinellia on saline coastal creekflats.
2. Trevor Egel (Mt Charles, Coorong Districts / Upper South East) – Mixed pasture of puccinellia, lucerne, clovers and barley on saline inter-dunal flats.
3. David Liddicoat (Ungarra, Eyre Peninsula) – alleyed saltbush with understorey ryegrass/ medic, and lucerne pastures in drained saline creekflats.
4. Trevor Beare & Martin Wilkinson (*Maro Creek*, Snowtown, Mid North) – alleyed saltbush with inter-row pastures on low-lying flats.
5. Malcolm Schaefer (Murray Lagoon, Kangaroo Island) – puccinellia and tall wheat grass in an ancient lake bed system.
6. Gordon, Neville & Brian Stopp (Mt Charles, Coorong Districts / Upper South East) – puccinellia on saline inter-dunal flats.
7. Charlie Bruce (Kingston, South East) – pucci and tall wheat grass on saline inter-dunal flats.

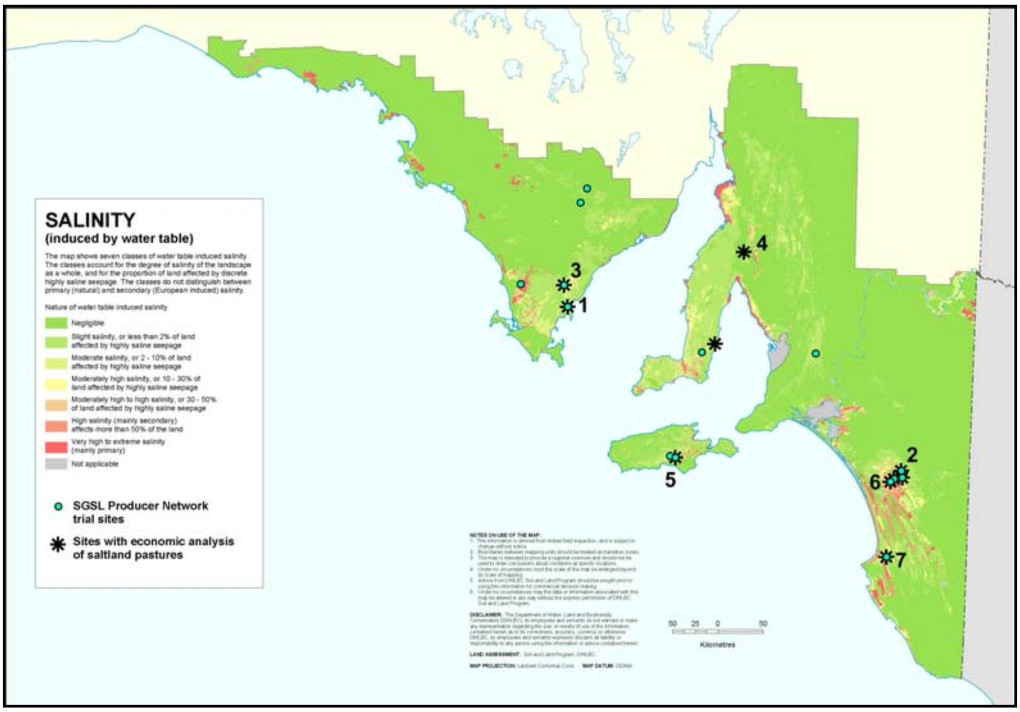


Figure 20. Locations of the saltland farmer case studies.

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GLOSSARY

Alluvial – Describes material deposited by, or in transit in flowing water.

Aquifer – A saturated geological material, that when drilled, can yield a useable quantity of groundwater.

Baseflow – The water in a stream that results from groundwater discharge to the stream. This discharge often maintains flows during seasonal dry periods and has important ecological functions.

Basement – Hard un-weathered bedrock.

Capability (of saltland) – The productive potential of land, as determined by a number of factors (relating to soils, landscape, climate), but in particular relating to the decline in productivity potential with increasing salinity. It can be quantified in DSE/ha for grazing land. Pasture options for optimising productivity will vary as saltland capability varies (eg. due to salinity & waterlogging conditions).

Catchment – An area of land that drains surface water to a common outlet. A catchment is usually made up of sub-catchments for the tributary streams to that river.

Colluvial – Describes material transported largely by gravity.

CRC Salinity – Cooperative Research Centre for Plant-based Management of Dryland Salinity.

Discharge – Outflow of groundwater as seepage from transverse flow, or as capillary rise from shallow watertables. This often produces the symptoms of dryland salinity (i.e. bare ground, salt crusts or waterlogging).

DM – Dry matter, a measure of pasture productivity (eg. kg DM/ha).

DSE – Dry sheep equivalent, a standard unit frequently used to compare the feed requirements of different classes of stock. By definition, a 50 kg wether maintaining a constant weight has a DSE rating of 1 (and an energy requirement of 8.5 to 9MJ/day).

DWLBC – Department of Water, Land and Biodiversity Conservation.

EC, ECe, EC 1:5 – see Sections 7.4 and 7.5.

Electromagnetic (EM) surveys – The detection and mapping of variability in sub-surface conductivity (spatially and with depth) through the application of electromagnetic fields to induce responses in buried conductive materials. The variability measured can be caused by the presence of salt, moisture, clayey materials and conductive minerals. Ground-truthing (via soil pit surveys) is required to correlate EM survey data to soil attributes such as salinity. Survey systems vary in complexity from hand-held meters to GPS-equipped, data-logging quad-bike systems and even airborne systems for larger scale (regional) surveys.

The ‘EM38’is one ground-based EM meter used to gauge salinity levels. It should be noted that the conductivity readings obtained by the EM38 are averaged over the measurement depth (0-60cm in horizontal mode or 60-120cm in vertical mode) rather than just in the plant root zone.

Groundwater – Underground water contained in a saturated zone of soil or geological strata.

Groundwater Flow System (GFS) – Different types of GFS characterise the scale of a groundwater system and are determined by the relief of the landscape and topographic position in a regional context. Aside from the scale of groundwater flow paths, the term GFS also encompasses notions of a range of hydrogeological attributes which help to describe groundwater system behaviour (eg. magnitude and delays in groundwater response to significant rainfall events or land use change).

Three broad classes of GFS are recognised:

- Local systems – occur in small sub-catchments in hilly areas. Flow paths between recharge and discharge areas are less than 5 km. Groundwater flow patterns correlate well with surface topography. These systems are the most responsive to recharge reduction strategies.

- Intermediate systems – occur in larger catchments with flat plateau or alluvial valley fills. Flow paths are in the range 5-50 km.
- Regional systems – occur in large sedimentary basins / broad riverine plains and have large horizontal flow scales, greater than 50 km. These larger systems can be sluggish in nature, taking longer to show signs of salinity, or be very responsive if geological materials are highly transmissive (eg. limestone aquifers). Depending on geology, they can be the least responsive to management changes. If engineering solutions (eg. drainage, groundwater pumping) are not possible, the use of saltland pasture is critical in the productive use of the saline land.

Inundation – Flooding of the land surface and plants by excess surface water and groundwater discharge over extended periods of time.

Recharge – Unused rainwater, or surface water inflows, which move down through the soil (below root zones) to the watertable and cause watertables to rise.

Salinity – Salinity refers to the presence of dissolved salts in soil and water. Salinity can be natural ('primary' salinity) or caused by land management practices ('secondary' salinity). In naturally saline areas, the plants and animals have evolved to cope with these conditions. In contrast, in areas of secondary (human-induced) salinity, a build up of salt can adversely impact on water, soil, vegetation or agricultural production. Salinity can occur with or without a watertable influence.

Salts in the root zone impede plant performance through osmotic effects (causing water to be drawn away from plant cells and into the more saline soil environment) and the slowing of plant metabolic processes. The rate and quantity of salts being deposited in the root zone depend on factors including groundwater depth and salinity, soil textures (which influence capillary action and potential flushing), rainfall, evaporation and landscape drainage.

Salinity types – The following types of salinity are generally recognised:

- *Dryland salinity*

  Dryland salinity is commonly used to describe secondary (human-induced) salinity, associated with saline seepage from shallow watertables in non-irrigated areas. Dryland salinity is attributed to increased groundwater flux following the widespread clearing of native vegetation. The groundwater causing the problem may be naturally saline or mobilise salts previously stored within the soil. Seepage to the surface can occur from upward hydrostatic groundwater pressure, when the watertable intersects the surface, or capillary rise enables salts to be deposited near the surface or within the plant root zone. Dryland salinity is widespread in the Upper South East, eastern and lower Eyre Peninsula and is locally significant on Yorke Peninsula, Kangaroo Island, within the northern agricultural districts and the Mount Lofty Ranges.

- *Dry saline land*

  Dry saline land is not associated with shallow watertables and occurs where salts are trapped in the subsoil or throughout the profile, typically due to the presence of an impermeable sodic clay subsoil. Dry saline land is also known as 'transient salinity', as salts can move up and down the profile with seasonal influences causing intermittent patchy growth and yield losses in crops and pastures. Where surface vegetation is severely degraded or absent and salt crystals form, the land is commonly termed 'magnesia ground'. Dry saline land is common around the northern fringes of Eyre Peninsula, throughout the West Coast agricultural district, and is scattered through the northern agricultural districts and northern marginal lands (including the southern Flinders area). Most soils of the lower rainfall districts have elevated salt levels in their subsoils, but magnesia ground (highly saline, bare dry saline land) is rare outside of Eyre Peninsula.

- *Irrigation salinity*

  Here similar salinity impacts to 'dryland salinity' are felt, due to groundwater discharge from shallow watertables. The difference is that the shallow groundwater (or groundwater mound) is caused by excess drainage of irrigation water past the plant root zone. This term can also describe salinity that arises due to insufficient leaching of salts in the applied irrigation water, which causes salts to build up in the surface soil.

Salinity units and measurement – The simplest measurement of salinity is to determine the electrical conductivity (EC) of a water sample. That is, how easily a solution will pass an electric current. This is done very simply using a salinity meter. Some meters convert EC to Total Dissolved Solids (TDS) using a conversion factor. See Section 7.3 to 7.5 for information on measurement methods and units.

SARDI – South Australian Research and Development Institute (see 'Contacts & websites').

SEWCDB – South Eastern Water Conservation and Drainage Board (see 'Contacts & websites').

SGSL – 'Sustainable Grazing on Saline Lands' Project. (See the introduction to this manual for more information.)

Sodic soil – A soil with a relatively high proportion of exchangeable sodium on the clay particles. This can cause soil structural problems. Saline conditions alleviate sodicity issues in soil, but when rain leaches out salts (freshening the soil water) this can cause clay particles to de-aggregate and disperse. The dispersed clay particles move through the soil clogging pores and reducing infiltration and drainage. On drying they can form a hard-setting layer. At an exchangeable sodium percentage (ESP) of 6 soils are deemed sodic, and in most cases will disperse at this and higher ESP values. Dispersion increases with increasing ESP and pH. Applying gypsum to alkaline soils (and/or lime to acid soils) will help to displace the sodium, and improve soil structure problems.

Soil structure – The way in which soil particles aggregate or group together. Well structured soils are those with higher clay contents in which the particles are held together as friable aggregates or crumbs. Pure sands have no structure.

Soil texture – is determined by the relative amounts of sand, silt and clay in a soil. Texture strongly influences soil properties such as structure, water infiltration, moisture and nutrient retention, plant-available water, trafficability and ease of tillage. Clays have a greater ability to absorb and store salts in solution than sands, therefore the conversion factor used to estimate ECe values from EC 1:5 values will depend on soil texture (see Tables 15 and 16).

Soit texture can be assessed in the field as follows (Anderson et al., 2007):

- Moisten a small handful of soil (adding small amounts of water at a time) while working the soil to form a ball (referred to as a 'bolus') slightly larger than the size of a golf ball.
- The bolus is at the appropriate moisture content when the surface just glistens.
- Press out the bolus between the thumb and the forefinger to form a ribbon.
- Use the following flow chart (Figure 21) to assist in determining soil texture.

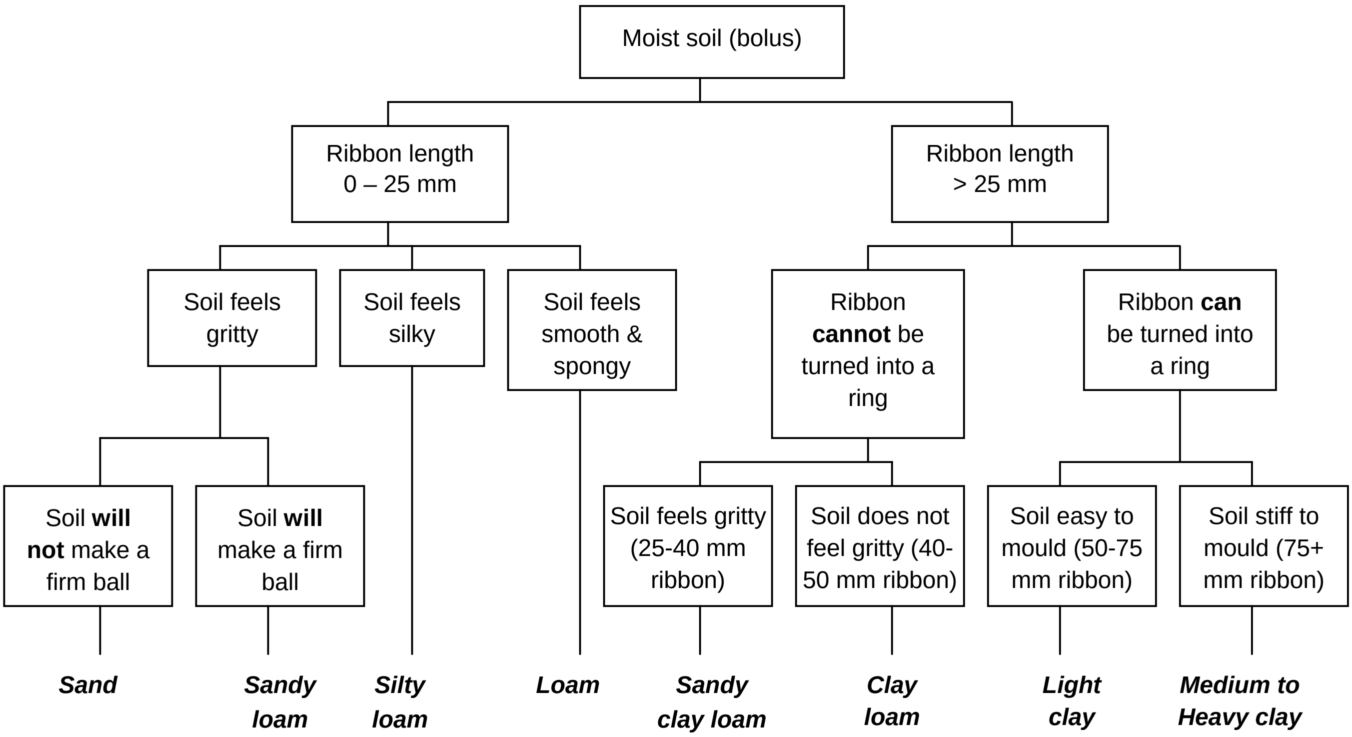

Figure 21. Flow chart for determining soil texture (Anderson et al., 2007).

Stolon – a prostrate stem, at or just below the surface of the ground that produces new plants from buds at its tips or nodes.

Surface water – Water in streams, creeks, rivers, lakes, dams, reservoirs and other surface water bodies.

Topography – Relief and form of a land surface.

Waterlogging – a soil is waterlogged if any part of the plant root zone is saturated with water. Severe waterlogging occurs when the soil is saturated to the surface for at least a few weeks. Indicators of waterlogging include continued wetness; presence of weeds such as rushes (*Juncus* spp.), water buttons (*Cotula* spp.) and/or sea barley grass; patchy or stunted crop and pasture growth; yellowing or reddening of leaves; excessive growth of algae; “rotten egg gas” smell from soil (a sign of anaerobic conditions); presence of dull yellow mottles (minor waterlogging) or blue-grey mottles (strong waterlogging) in the soil profile.

Watertable – Is the presence of water in near surface soils at supersaturated levels. The watertable level is the surface in an unconfined aquifer where the pore water is at atmospheric pressure. It is the height to which the water level will rise in a well drilled in an unconfined aquifer.

CONTACTS AND WEBSITES

AUSTRALIA-WIDE…

CanPrint Communications

Web: www.canprint.com.au
PO Box 279, Fyshwick ACT 2609
Tel: 1800 776 616 (or 02 6293 8383),
Fax: 02 6293 8388
Email: support@canprint.com.au
[To order *SALTdeck* – quote product number PB061190]

Cooperative Research Centre for Plant-based Management of Dryland Salinity (CRC Salinity)

Web: www.crcsalinity.com.au
C/- The University of Western Australia M081
35 Stirling Highway, Crawley WA 6009

CRC Salinity fact sheets:
www.crcsalinity.com.au > Publications > Key publications > Factsheets

Grassland Society of Southern Australia Inc.

Web: www.grasslands.org.au .
PO Box 1387, Echuca VIC 3564
Tel: 03 5480 3305, Fax: 03 5480 3033
Email: office@grasslands.org.au
[website includes a pasture species database]

Land Water and Wool / SGSL sub-program

Web: www.landwaterwool.gov.au > research > Sustainable Grazing on Saline Lands

Lifetime Wool (Australian Wool Innovation research & extension project)

Web: www.lifetimewool.com.au

Timerite®

Program for managing red legged earth mite.
Web: www.timerite.com.au

FOR SOUTH AUSTRALIA…

Adelaide and Mount Lofty Ranges Natural Resources Management (AMLR NRM) Board

Web: www.amlrnrm.sa.gov.au
205 Greenhill Road, Eastwood SA 5063
Tel: 08 8273 9100
Email: reception@adelaide.nrm.sa.gov.au

Coorong Districts Local Action Planning (LAP) Group

Web:www.rivermurray.sa.gov.au/lapgroups/coorong
PO Box 1021, Tintinara SA 5266

Contacts: Lesley Cameron or Graham Gates
Project Officers
Tel: 08 8757 2100, Fax: 08 8757 2222
Email: LCameron@coorong.sa.gov.au

Department of Water, Land and Biodiversity Conservation (DWLBC)

Web: www.dwlbc.sa.gov.au
GPO Box 2834, Adelaide SA 5001
Tel: 08 8463 6800 (General enquiries)

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Eyre Peninsula Natural Resources Management (EP NRM) Board

Web: www.epnrm.sa.gov.au
PO Box 2916, Port Lincoln SA 5606
Tel: 08 8682 5655, Fax: 08 8682 5644
Email: Kate.Clarke@epnrm.com.au
[General Manager: Kate Clarke]

Kangaroo Island Natural Resources Management (KI NRM) Board

Web: www.kinrm.sa.gov.au
Shop 3, The Mall, Dauncey Street, Kingscote

PO Box 665, Kingscote SA 5223
Tel: 08 8553 0111, Fax: 08 8553 0122
Email: info.kinrmboard@bigpond.com

Landcare (SA)

Web: www.landcaresa.org.au
Tel: 1800 818 467
Email: landcare@saugov.sa.gov.au

Northern & Yorke Natural Resources Management (N&Y NRM) Board

Web: www.nynrm.sa.gov.au
41-49 Eyre Road, Crystal Brook
PO Box 175, Crystal Brook SA 5523
Tel: 08 8636 2361, Fax: 08 8636 2371
Email: Des.Bilske@nynrm.sa.gov.au
[General Manager: Des Bilske]

Roseworthy Information Centre (& online bookshop)

Web: www.ruralsolutions.sa.gov.au/bookshop
Norton Road, Roseworthy Campus
PO Box 1745, Gawler SA 5118
Tel: 1800 356 446 (Free call)
Fax: 08 8303 7629
Email: farmer.info@saugov.sa.gov.au

Rural Solutions SA

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GPO Box 1671, Adelaide SA 5001
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Email: info@ruralsolutions.sa.gov.au

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Cleve Office
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Tel: 08 8628 2091, Fax: 08 8628 2512

Jamestown Office
17 Irvine Street
Tel: 08 8664 1408, Fax: 08 8664 1405

Kadina Office
35 Frances Terrace
Tel: 08 8821 1555, Fax: 08 8821 1082

Keith Office
Anzac Terrace
Tel: 08 8755 3166, Fax: 08 8755 1686

Kingscote Office
Shop 7, The Mall
Tel: 08 8553 4949, Fax: 08 8553 2930

Lenswood Office
Swamp Road
Tel: 08 8389 8800, Fax: 08 8389 8899

Loxton Office
Bookpurnong Road
Tel: 08 8595 9100, Fax: 08 8595 9199

Mt Barker Office
Cnr Mann & Walker Streets
Tel: 08 8391 7500, Fax: 08 8391 7521

Mt Gambier Office
9 Krummel Street
Tel: 08 8735 1300, Fax: 08 8723 1941

Murray Bridge Office
Cnr Seventh St & South Tce
Tel: 08 8535 6400, Fax: 08 8535 6427

Nuriootpa Office
Research Road
Tel: 08 8568 6400, Fax: 08 8568 6449

Port Augusta Office
12 Tassie Street
Tel: 08 8648 5161, Fax: 08 8648 5161

Port Lincoln Office
5 Adelaide Place
Tel: 08 8688 3400, Fax: 08 8688 3407

Renmark Office
117 Ral Ral Avenue
Tel: 08 8586 6761, Fax: 08 8586 5848

Streaky Bay Office
15 Bay Road
Tel: 08 8626 1108, Fax: 08 8626 1671

Struan Office
Penola Road (Riddoch Hwy)
Tel: 08 8762 9100, Fax: 08 8764 7477

Victor Harbor Office
34 Victoria Street
Tel: 08 8552 7788, Fax: 08 8552 7811

South Australian Murray-Darling Basin Natural Resources Management (SA MDB NRM) Board

Web: www.samdbnrm.sa.gov.au
PO Box 2343, Murray Bridge SA 5253
Tel: 08 8532 1432, Fax: 08 8532 5300, or

PO Box 1374, Berri SA 5343
Tel: 08 8582 4477, Fax: 08 8582 4488

South Australian Research & Development Institute (SARDI)

Web: www.sardi.sa.gov.au
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South East Natural Resource Management (SE NRM) Board

Web: www.senrmb.com.au
PO Box 30, Mount Gambier SA 5290
Tel: 08 8724 6000, Fax: 08 8723 2965
Email: nrm_admin@senrm.sa.gov.au

South Eastern Water Conservation and Drainage Board (SEWCDB)

PO Box 531, Millicent SA 5280
Cnr Park Terrace & Aberle Street
Tel: 08 8733 3533, Fax: 08 8733 4796
Email: Talanskas.Mike@saugov.sa.gov.au
[General Manager: Mike Talanskas]

Upper South East Dryland Salinity and Flood Management Program

Web: www.dwlbc.sa.gov.au > Land management > Programs: USE Dryland Salinity and Flood Management Program
GPO Box 2834, Adelaide SA 5001
Tel: 08 8303 9653
Fax: 08 8303 9744
Email: useprogram@saugov.sa.gov.au

FOR WESTERN AUSTRALIA…

Department of Agriculture & Food

Web: www.agric.wa.gov.au > Land, Water + Environment > Salinity

Saltland Pastures of WA (Inc.)

Web: www.crcsalinity.com.au/spa
Tel: 08 9865 1205
Fax: 08 9865 1282
Email: spa@agric.wa.gov.au
[SPA Project Manager: Sally Phelan]

FOR VICTORIA…

Department of Primary Industries (Vic DPI)

Web: www.dpi.vic.gov.au > Agriculture & Food > Crops pastures & weeds > Information notes – crops & pastures
Private Bag 105, Hamilton VIC 3300
Tel: 03 5573 0900

FOR NEW SOUTH WALES…

Department of Primary Industries (NSW DPI)

Web: www.dpi.nsw.gov.au > Agriculture > Publications > Fact sheets
(see ‘Agfacts’, ‘Agnotes’ & ‘Primefacts’)

CD-ROM

A selection of useful resources is contained on the CD-ROM attached at the back of this manual.

CONTENTS OF THE CD-ROM

Drainage information

- Drainage factsheets from the USE Dryland Salinity & Flood Management Program, and from the former Eyre Peninsula INRM Group.
- Information sheets on various types of drains from the National Dryland Salinity Program.

Native vegetation guidelines & weed potential

- Summary of native vegetation regulations relating to saltland pasture development and management (from DWLBC and Native Vegetation Council).
- DWLBC fact sheet on the environmental weed risk posed by species used in salinity management.

Pastures

- A range of fact sheets for pasture species and their management.

Profitability calculator

- An Excel® spreadsheet tool for determining the profitability of saltland pasture establishment and the sensitivity of pasture systems to different economic variables (developed by Senior PIRSA Economist Graham Trengove).

SGSL farmer case studies with example economics analyses

- 7 stories of success with saltland pastures (refer to Section 13 'Case studies')

SGSL trial site summaries

- 2 page summaries of the SGSL Producer Network trials. (The location of these trial sites are shown in Figure 20, Section 13, but note that numbering for this figure refers to case studies only.)

Soils & measuring salinity

- DWLBC fact sheet describing the extent of available soils mapping in South Australia.
- Fact sheets for measuring & interpreting salinity levels.

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