The Economic Value of Improving Pasture Production on Saltland in Southern Australia

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A Report of the Economics Theme
Sustainable Grazing on Saline Land Program
Land Water & Wool

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Summary

The cause of dryland salinity and the impact on the environment and agricultural productivity of agricultural land is well documented. A significant proportion of agricultural land in Australia is degraded as a result of dryland salinity and the land at risk of degradation from rising water tables is even greater. Much of the area of land affected by salinity cannot be reclaimed profitably and may have adverse consequences for neighbouring properties, reserves and waterways. Introducing production systems that are adapted to waterlogged and saline soils is likely to be the only feasible management option for these areas. Only salt land pasture is likely to be profitable at the scale required to provide a management option for the majority of land affected by salinity.

The Sustainable Grazing for Saline Land (SGSL) initiative was developed with a number of partner organisations throughout southern Australia to identify and promote profitable grazing systems on otherwise unproductive land. Six key issues were identified and research was conducted across five sites in the four southern mainland states of Australia. The broad issues researched were: salt and water movement, pasture performance, animal performance, biodiversity, additional pasture species and systems economics. Results for each research site were published in separate reports.

This paper reports the findings of the Economics Theme. The main aims of the Economics Theme were:

1. To provide assessments of the economic value of forage produce from salt-tolerant perennial pastures at each of the SGSL research sites;
2. To identify the economic constraints to the adoption of saltland pastures;
3. Understand the factors affecting the profitability of saltland pasture systems;
4. Provide estimates of the value of additional pasture supply from saltbush to identify potential areas of future research and development;
5. To update whole-farm models for each of the southern states with the latest production data for saltland pastures and livestock systems.

Mathematical programming provides a very useful method of analysis for assessing the profitability of new grazing systems and pasture species. A large number of production options can be described, in addition to the resources constraints confronting farmers. This capacity enables the whole farming system to be represented, including the interrelatedness of production enterprises, such as rotational influences on crop and pasture production and input levels. For these reasons mathematical programming models were applied to the economic analysis of SGSL data.

MIDAS is a suite of models that have been developed for a number of different regions of Western Australia, south-west Victoria and the slopes of New South Wales. MIDAS was the model of choice in for these analyses.

There were four study regions as part of this project, based in the local of research sites of the SGSL Program. These were south west Victoria, Upper South East of South Australia, the

Central Wheatbelt of Western Australia and the Central West Slopes of NSW. The analyses for each region examined the benefits of introducing improved pasture species and applying different management treatments to saltland. The effect of changing production assumptions and commodity prices on the profitability of saltland pasture were estimated. The factors examined were: pasture growth, pasture quality, wool and meat prices, area of saltland, cost of establishment, type of sheep enterprise and the presence of lucerne.

Introducing improved pasture species to salt affected land to increase the feed value for livestock is profitable across a broad range of environments, production conditions and commodity price assumptions, according the results of this study.

The extent to which farmers can achieve the increases in profit suggested by this study will depend critically on their ability to manage the livestock enterprise to achieve the production levels assumed. Pasture quality and growth were shown to have a major effect on the profitability of improved pastures. Maintaining pasture quality of perennial species requires good grazing management, as long periods of deferment will lead to substantial reductions in feed value. The models used in this study typically selected high stocking rates to increase farm profit when improved pastures on saltland were introduced. This was accompanied by increases in the amount of supplementary feeding in some cases.

It was generally the case that higher farm profit was achieved by increasing the intensity of production. This has potential implications for adoption of improved saltland pastures and consequently for extension; namely that factors that may limit the ability of farmers to increase intensity of production need to be understood and addressed if widespread adoption is likely to occur.

Introduction

Clearing of land for agriculture in Australia has been a significant factor in driving regional development since European settlement. This development has produced a range of negative impacts on the natural environment. One such problem is rising water tables and the consequent transport of stored salts to the soil surface. The cause of dryland salinity and the impact on the environment and agricultural productivity of agricultural land is well documented (see Coram *et al*, 2001, Keighery, 2000 and Kingwell *et al*, 2003). A significant proportion of agricultural land in Australia is degraded as a result of dryland salinity and the land at risk of degradation from rising water tables is even greater (Anon, 2001)

Broadly speaking, dryland salinity may be managed in three ways: prevention by reducing the drainage of water past the root zone of plants, remediation or reclamation by removing saline discharge and salts that have accumulated at or near the soil surface, and adaption which involves introducing a production system that is able to cope with the high level of salt and/or water (Pannell, 2001).

Much of the area of land affected by salinity cannot be reclaimed profitably (Coles *et al*., 1999), and may have adverse consequences for neighbouring properties, reserves and waterways. Introducing production systems that are adapted to waterlogged and saline soils is likely to be the only feasible management option for these areas.

A number of studies have reviewed the alternative uses of saline land. Options include energy generation, mineral extraction, aquaculture, forestry, horticulture and salt tolerant pastures for grazing. However only salt land pasture is likely to be profitable at the scale required to provide a management option for the majority of land affected by salinity.

The Sustainable Grazing for Saline Land (SGSL) initiative was developed with a number of partner organisations throughout southern Australia to identify and promote profitable grazing systems on otherwise unproductive land. Six key issues were identified and research was conducted across five sites in the four southern mainland states of Australia. The broad issues researched were: salt and water movement, pasture performance, animal performance, biodiversity, additional pasture species and systems economics. Results for each research site were published in separate reports.

In addition, themes that were common to all sites were identified and theme projects formed. The main aim of the themes was to ensure consistency of data collection and analysis across sites where possible and provide data interpretation between sites to determine the extent to which the viability of saltland pasture is affected by the different production environments.

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Method

Farm modelling

Mathematical programming provides a very useful method of analysis for assessing the profitability of new grazing systems and pasture species. A large number of production options can be described, in addition to the resources constraints confronting farmers. This capacity enables the whole farming system to be represented, including the interrelatedness of production enterprises, such as rotational influences on crop and pasture production and input levels.

Detailed representation of the production relationships of farms makes explicit assumptions used in the analysis making them more accessible. Making the assumptions explicit enables the influence of these assumptions on the model results easier to examine. This is in contrast to many analyses undertaken using simpler approaches such as budgeting or gross margins, where many assumptions are implied.

Most importantly however, using a detailed model will provide a more realistic assessment of the impact of new technologies or changes in management on farm profit. Non-linear production relationships will often result in non-linear profit responses to changes in the farming system. This implies that the gross margin of an enterprise will often change as enterprise mix is altered. This change can be difficult to estimate using simpler methods of analysis.

For these reasons mathematical programming models were applied to the economic analysis of SGSL data.

Description of study regions

South West Victoria

Location

The trial site in this region was located near Dunkeld which is around 250 km west of Melbourne and 100 km from both the eastern and western boundaries of the designated study region. The northern and southern boundaries were determined by the 550mm and 750mm annual rainfall isohyets respectively. Reserves and major tracts of native vegetation have been excised from the map (Figure 1).

Climate

The climate can be broadly described as Mediterranean, with a cool wet growing season, where rainfall exceeds evapotranspiration and warm relatively dry summers. The study region has annual rainfall of between 550 and 650 mm, 80% of which falls in the growing season (Table 1). The break of the season is typically around late March and season finish is in early

December. Whilst summer rain is a small proportion of the total the variability is low compared with other regions of southern agricultural areas

Soils

A basalt plain is the dominant land form in the study region. Within this plain there are areas of shallow, underdeveloped soils that are infertile, while others have developed over a longer period and are more fertile supporting high levels of production. Consecutive lava flows have also interrupted drainage lines, so much of the plain is poorly drained and subject to water logging and inundation. In some areas salinity levels also limit the production of many agricultural plants species.

Sedimentary soils formed by marine deposition make up a smaller proportion of the region, . These are older soils and typically low in fertility with a sandy top soil and heavier subsoil. Old lake beds contain heavy clay soils included cracking clays. These are often sodic and poorly drained.

Main Enterprises

Sheep meat and wool is the dominant enterprise. Livestock are grazed on productive mixed pastures of mixed perennial and annual species. Sheep farmers often sow a small proportion of the farm to crop for feed grain. Dairy and beef enterprises are important to regional economies but only a minor in terms of total area in the study region shown in Figure 1. Cropping, horticulture, forestry and viticulture are also minor enterprises.

Table 1: Comparative production and climate characteristics of study regions

	SW Vic	Upper SE SA	Central Wheatbelt	Central West NSW
Annual RF (mm)	700	450	350	600
Growing season RF (%)	80%	70%	80%	50%
Summer RF variability	moderate	moderate	Extreme	Mod – High
Crop area (%)	<10%	<10%	50-60%	<50%
Ave stocking rate (est.)	11-13	6-7	4-5	8-10
Season break	Late March	Early May	Early May	Early April
Season finish	Early Dec	Early Nov	Early Oct	Late Nov

Upper South East of SA

Location

The study region is part of the Upper South East of South Australia. It is about 200 km from Adelaide and bounded in the east by the towns of Keith and Naracoorte and the coast in the west. The region lies south of the 450 mm annual rainfall isohyet and just to the north of the 650 mm rainfall isohyet (Figure 2).

Climate

The climate of the Upper South East is broadly similar to south west Victoria. Winter is wet and cool while summers are hot. However this region has lower annual rainfall compared to SW Victoria (Table 1), with a later season break in early May and an earlier finish, in early November. This limits production levels and livestock carrying capacities of farms are therefore lower. Average daily maximum temperatures are 2-3 degrees warmer all year round. The variability of rainfall, as measured by the Bureau of Meteorology index, is slight higher compared to SW Victoria between December to April.

Soils

Soils are predominately sandy overlying clay and a limestone that slopes gently westward. They are typically low in natural fertility and were only cleared within the past 60 years when trace elements were identified as a major factor limiting productivity. Drainage of these soils was generally limited by the slight gradient to the coast and a series of dune systems that run parallel to the coast. Large areas of land are subject to waterlogging and dryland salinity, although the majority of affected land has low salinity. In recent times a network of drainage canals was constructed, but large areas of land remain affected by high water tables.

Main enterprises

Wool production is the dominant enterprise in the region, while beef and dairy production is the focus for a minority of businesses. Intensive cropping is practiced in some areas. Horticulture is a major enterprise in terms of value, particularly wine grape production.

Pastures consist and a mix of perennial and annual species. Lucerne is typically grown on the deeper soils while other perennial species such as tall whet grass is recommended for the shallow soils less affected by waterlogging and salinity.

Central Wheatbelt of WA

Location

This study region is part of the Central Wheatbelt just over 100 km east of Perth. It is comprised of the Corrigin, Quairading and Dowerin Shires. The 350 mm rainfall isohyet runs through the centre of the regions.

Climate

The Central Wheatbelt of WA has a broadly similar climate to the regions in SA and Victoria. However the average annual rainfall is lower (Table 1) and less than 20% of this falls outside the growing season. Rainfall over the summer is also much more variable compared to the Upper South East of SA and SW Victoria. The summer maximum daily temperature during summer is over 30 degrees celsius on average which is around 10 degrees higher compared to south western Victoria. The growing season is also much shorter compared to study regions in the east (Table 1).

Soils

There is a large variation in soils of the region. They have been developing on an ancient landscape, resulting in highly weathered, highly leached, infertile, coarse textured soils with poor structure. Heavier more fertile soils have developed in lower parts of the dissected landscape. Farms are heterogenous in terms of the mix of soils, with eight main land management units described for the typical farm for the region.

Main enterprises

Mixed crop-livestock farms make up the majority of farm businesses. The average crop area is between 50-60% although this is varies significantly depending on the mix of soils on each farm and farmer preference. The major crops grown in the region include wheat, barley, lupins and canola. Sheep are the dominant livestock which are grazed mainly on annual pasture, although a small area of perennial species are grown. Wool production makes up the majority of the sheep enterprise, by value of production, although prime lamb production has increased in recent years as a result of improved prices.

Central West Slopes of New South Wales

Location

The Central West slopes is around 250 km from the NSW coast It covers the western slopes of the Lachlan and Macquarie River catchments. It is bounded by the 700 mm rainfall isohyet and the 400 metre altitude contour. Boorowa lies in the south of the region while Wellington lies in the north.

Climate

The region has a temperate climate with average annual rainfall of around 600mm. Rainfall is spread evenly throughout the year although it is slightly summer dominant in the north and slightly winter dominant in the south. Rainfall is more variable in the warmer months compared to the SA and Victorian study regions (Table 1), where storms develop along low pressure troughs fed by moist tropical air. Winter rainfall is less variable and typically precedes frontal systems that develop to the south of the continent. The Central West Slopes has a relatively long growing season compared to the SA and WA regions, typically starting in early Arpil and finishing in November (Table 1).

Soils

The region is comprised of complex geological formations that have had a marked influence on the formation of the soils. The soils are largely derived from the bedrock material that is predominantly granitic with some sedimentary parent material. Volcanic intrusions are interspersed within the older more weathered material, leading to a broad range of soils with differing characteristics, from weak, naturally acidic and sodic soils to more robust, fertile soils. The region is typically undulating and on many properties slope of the land has a significant influence on land use.

Main Enterprises

This is a traditional wool growing area where livestock is the dominate enterprise in the mixed enterprise farms of the region. During the mid 1990’s the majority of land was under pasture, with around 30% of the total area under crop in the north of the region and less than 10% in the south. There has more recently been a shift toward cropping but more than half of the total agricultural area remains under pasture. Whilst relative prices have an influence on the balance of crop and pasture soil limitations are the dominate factor, thus limiting the extent of the expansion of cropping.

Implications for management

The difference in climate between the regions has important implications for livestock production, particularly in the Central Wheatbelt. Firstly, perennial species are generally less successful in environments with shorter growing seasons and where summer rainfall is low and variability high. Secondly, shorter growing seasons demand that livestock be carried for longer on dry feed. Hence the cost of supplementary feeding is higher or the carrying capacity for livestock is more limited. Optimum stocking rates are therefore be much lower in the Central Wheatbelt and hence the value of saltland pasture is likely to much lower. Farms in the Central West Slopes of NSW on the other hand have higher carrying capacities because there is more uniform annual average rainfall. This provides a longer growing season and enables summer active perennials to thrive. There is a potential trade-off however, as the economic viability of salt tolerant perennials will depend on the extent to which they compete with other perennials such as lucerne. The viability of salt tolerant pasture will depend critically on the extent of utilisation by livestock. This will be affected by the supply of other feed sources and the extent to which they limit stocking rates.

Description of representative farm model

MIDAS is a suite of models that have been developed for a number of different regions of Western Australia (Blennerhasset & Bathgate, 2000; Morrison *et al.*, 1986; Morrison & Young, 1991), south-west Victoria (Thompson & Young, 2000) and the slopes of New South Wales (Bathgate & Hoque, In Progress). A full description of the model can be found in Kingwell and Pannell (1987).

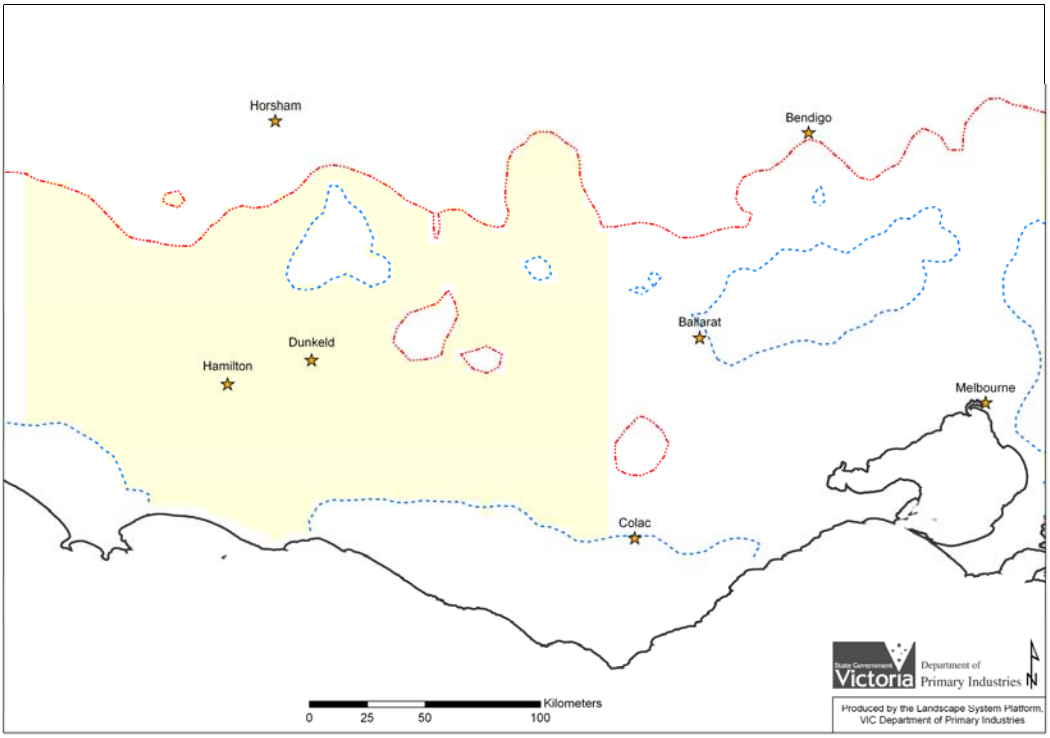

Figure 1: ‘Footprint’ of the Dunkeld Model for South Western Victoria.

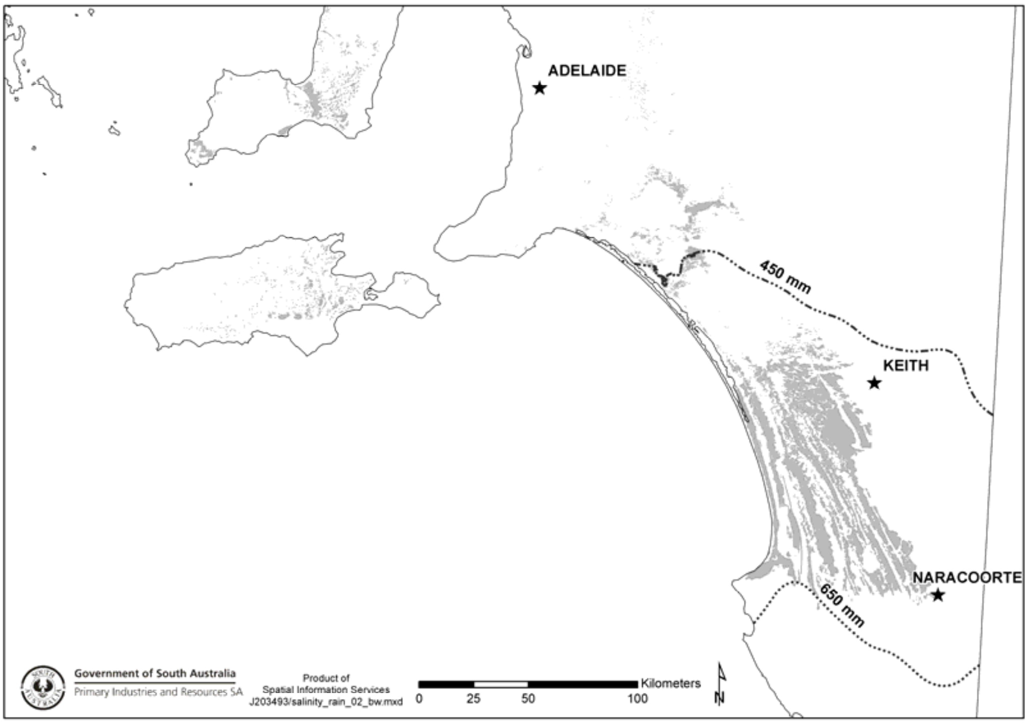

Figure 2: ‘Footprint’ of the Upper South East Model for South Australia.

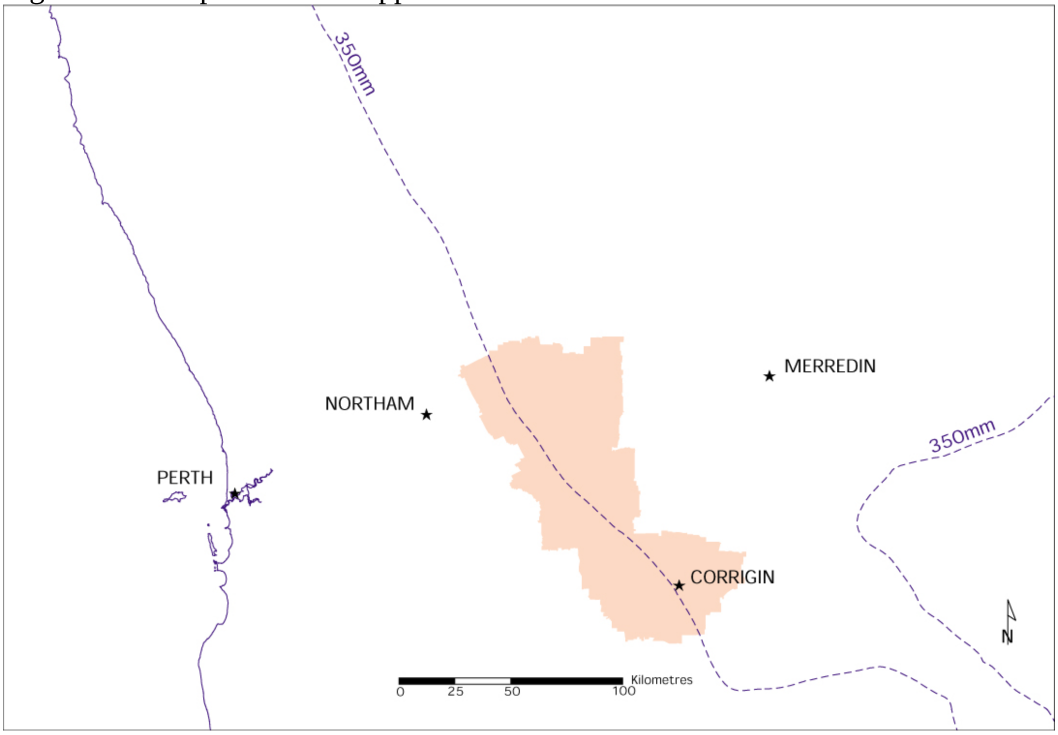

Figure 3: ‘Footprint’ of the Central Wheatbelt Model of Western Australia

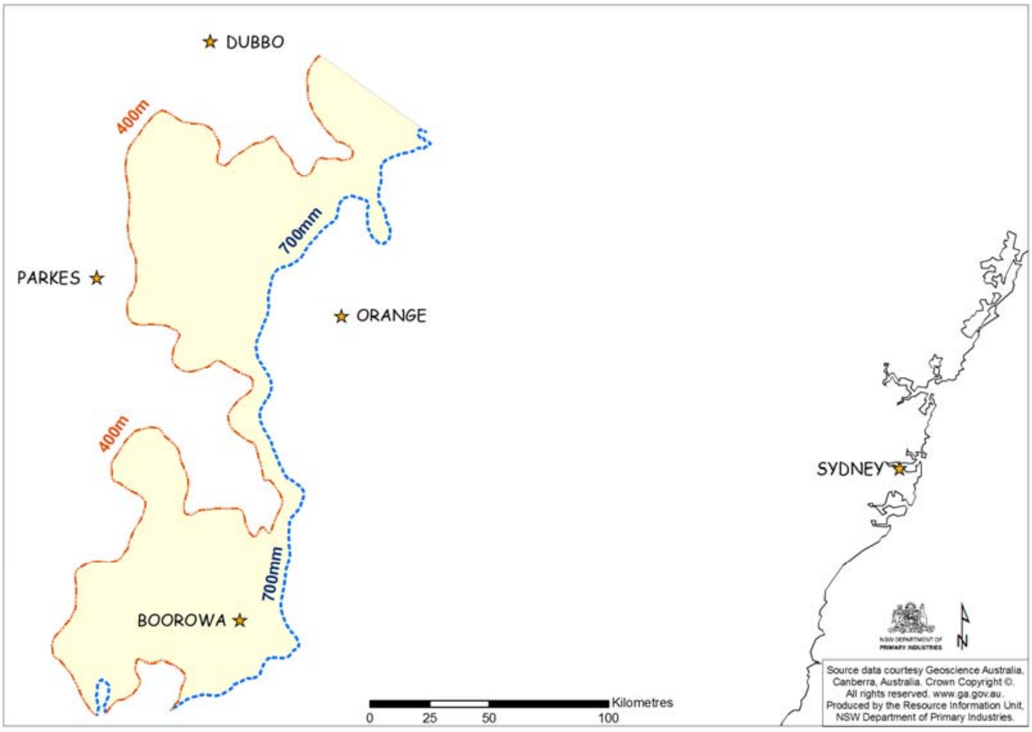

Figure 4: ‘Footprint’ of the Central West Model for New South Wales

Whilst there have been a number of refinements to the first version, described in Kingwell and Pannell (1987), to better reflect the farm production relationships, the fundamental structure of the model has not altered. The most significant change has been the description of pasture growth. More recent versions of MIDAS relate the rate of pasture growth to the amount of green feed on offer to livestock, whilst earlier versions assumed a constant rate of growth. This was an important refinement as the value of deferred pasture is better represented and provides more realistic estimates of the optimal stocking rate (Bathgate, 2006).

Each version of the model describes the production and resource constraints of a typical farm for a particular region. The yields and costs reflect the ability of a manager that is better than average (around the top 3rd decile of farmers in the region). Each version has a ‘footprint’, that shows the area for which there is a very high probability that the model is representative of farm production (Figures 1 to 4).

Components of the model

The model is comprised of number different components of the farming system. The following description of the model components have been modified from Blennerhasset and Bathgate (2000):

(i) Crop/ pasture rotations
Cropping history (or rotation) is represented by up to 80 different activities for up to eight land management units described in the model.

(ii) Machinery
Represented by a single activity that describes the availability of machinery to sow crops and pasture during four periods after the break of the season. This constrains the area of crop that can be sown and the reductions in crop yield that occur as a result of delayed sowing.

(iii) Time of sowing penalties
On average, maximum crop yield is achieved when crops are sown within a narrow window after the break of season. Crops sown outside this window have reduced yields. The model describes the relationship between yield reduction and areas of crop sown, based on the availability of machinery.

(iv) Grain, wool and livestock selling
Selling activities in the model link the physical output of the model with the cashflow and objective function.

(v) Pasture production
The season is divided into 10 periods of varying length depending on the growth rate of pasture and pasture quality. For annual pastures there are typically five periods of growth and five periods of senescence and pasture decline. Species with deeper roots may have an extended growing season to Period 6, while perennial species may grow throughout the year.

(vi) Livestock production
A large number of livestock classes are described. These differ in the demand for energy, time of selling and wool production and quality. A number of activities are inlcuded to allow selection of different patterns of liveweight amd production levels for a given livestock catergory

(vii) Supplementary feeding
Alternative sources of supplementary feed are available to ensure adequate supply of energy over the summer drought. The cost of feeding a storage, quality and wastage factors differ between the different grain types

(viii) Stubble grazing
Crop residues provide an additional source of feed for livestock during the summer drought. The quality and quantity of stubble available for grazing deteriorates with time and with grazing.

(ix) Finance
Income and expenditure associated with each activity are described in the cashflow section of the model. Overheads and depreciation are subtracted from the net cashflow to calculate farm profit.

The model is described in more detail below.

Soil Classes

Up to eight land management units (LMU) are described in MIDAS. The Central Wheatbelt and Central West versions have the maximum compliment, while the Upper South East and South West Victoria models have three and two land management units respectively. LMUs are an aggregation of soil types that have the same production levels for a given level of inputs and management. It is implied that all soils within an LMU have similar chemical and physical characteristics.

Crop and pasture production options

A large number of different crop and pasture sequences (or rotations) are possible on each LMU. Each rotation has specific crop yields, pasture growth and inputs levels. Pulse crops reduce the carryover of cereal diseases and fix soil nitrogen, for example. This affects potential cereal yield and optimum nitrogen rate. The number of continuous years of crop affects the ability of pastures to regenerate naturally and thus the number of livestock that can be grazed profitability is affected.

Up to 12 crop and pasture types are included in MIDAS, although most models have only a subset of these. The options are:

i. Wheat
ii. Barley
iii. Canola
iv. Oats
v. Tricitcale
vi. Lupins
vii. Field peas
viii. Faba beans
ix. Chick peas
x. Annual pastures (mixed sward)
xi. Summer dormant perennial pasture
xii. Summer active perennial pasture

No crop options are described in the South West Victoria model and the Upper South East Model.

Annual pasture production

An annual pasture is a mixed sward of grasses, herbs and legumes. Feed availability is divided into 10 periods; periods 1-5 representing the growing season of annual pasture, with germination of pasture occurring in Period 1. Periods 6-10 represent the decline on quality and quantity after senescence. Each period varies in length according to growth rate and pasture quality (digestibility).

Germination is dependent on soil class and crop/pasture sequence. Growth rate in subsequent periods is a function of feed on offer (kg of dry matter per ha), and represented by linear piecewise approximation. Feed on offer (FOO) is a function of FOO at the beginning of the period, the amount of pasture grazed by livestock during the period and the rate of physical deterioration and trampling by livestock

Pasture quality and quantity decline rapidly after senescence (Periods 6–10). Conservation constraints prevent over grazing of pastures and crop residues. Further detail on the representation of pasture production can be found in O'Connell *et al.* (2000).

Stubbles

Crop residues can be a source of high quality feed for livestock after harvest. Sheep preferentially graze the high quality components of the stubble so the quality of stubble declines as it is grazed. Conservation constraints limit the total amount of dry matter available for grazing.

Sheep production

Merino and merino-cross livestock options are described in the model. Ewes may be bred to replace those culled or merino-cross ewes may be purchased for prime lamb production. Different classes of sheep describe differences in age, times of sale and gender. Wethers can be sold as store lambs, spring lamb, carryover lambs or held to be sold as shippers or for wool production. Ewe lambs can be sold or kept and mated to a merino ram or terminal sire. Ewes are culled after five or six years. Death rates, annual wool growth and hauter are a function of the liveweight of each sheep class. Liveweight of ewes also affects lambing rates. Liveweights of animals are a function of the availability and quality of feed. Production relationships were based on CSIRO research (Standing Committee on Agriculture, 1990).

Finance

Cash payments for inputs and income are described in a bi-monthly cashflow. Provision has been made to enable an overdraft. Interest is paid on bimonthly deficits and earned on surpluses. The objective function is equal to the net cashflow at the end of the year, less depreciation of machinery and infrastructure, less the opportunity cost of non-land assets.

Model data for the analysis of saltland pasture

The following section shows the key data used in the analysis of the SGSL experimental sites. The general model assumptions and data are available by obtaining the Excel spreadsheets directly from the authors.

Feed periods

Table 2 shows the start dates for each of the 10 periods of pasture growth and decline for each of the regions. The periods were classified using data generated using Grassgro, a pasture simulation model (Moore *et al.*, 1997). Long term average growth rates were estimated by running a number of simulations over a long sequence of weather years (typically 100 years) at different stocking rates. Average weekly growth rates at different levels of feed on offer were extracted from the model output. Weeks with similar growth rates and/or pasture quality were then aggregated into Periods.

Growth rates and quality for each site were estimated, rather than using actual measured data. Growth rates for SW Victoria and the Upper South East were estimated using Grassgro, while estimates were made for the other two sites estimates of growth rate were based on adjusted trial data to remove the influence of seasonal variation.

This approach was used for two reasons. Firstly the model used in this analysis is a year-in-year-out model and hence is unable to described season sequences (although the affect of different productions levels on farm strategy and whole farm profit can be assessed). The other reason is that the trials under this program were conducted for a relatively short period of time, so the impact of a range of seasonal conditions on productivity could not be assessed.

Table 2: Start dates for pasture periods

Period	Central Wheatbelt	South West Vic	Upper South East	Central West
1	10 May	25 Mar	6 May	8 Apr
2	24 May	22 Apr	27 May	13 May
3	14 Jun	3 Jun	1 July	29 July
4	19 Jul	19 Aug	5 Aug	26 Aug
5	13 Sep	9 Sep	30 Sep	28 Oct
6	11 Oct	9 Dec	11 Nov	25 Nov
7	1 Nov	23 Dec	16 Dec	16 Dec
8	6 Dec	20 Jan	22 Jan	20 Jan
9	1 Mar	18 Feb	26 Feb	18 Feb
10	26 Apr	10 Mar	1 Apr	18 Mar

Saltland pasture growth rates and quality

Saltland pasture is described differently in each region. Generally there are two methods used to describe growth of saltland pasture. The first method is the same as that used for describing the growth rates of annual pasture. Growth outside the growing season is assumed to be constant, based on rotational grazing. Saltland pasture is unable to be deferred in the period P6-10. This restrictive assumption is imposed because deferment will lead to a change in quality of the pasture which is not described in these versions of MIDAS. This method of representing saltland pasture is applied to the Victorian and South Australian versions of the model.

The other method used assumes a fixed growth rate in each period, implying a set pattern of rotational grazing throughout the whole year. Deferment is permitted during P1-5 but not permitted outside the growing season for annual pastures.

Species used in the SGSL trials at each site are described in Table 3 while pasture growth rates and quality for saltland pastures on each sites are shown in Tables 4 & 5.

Table 3: Overview of pasture production assumption for farm models in each of the study regions

	Central Wheatbelt	SW Vic	Upper SE SA	Central West NSW
Farm size (ha)	2000	700	2000	900
Area of saltland (ha)	200	50	800	20
Salinity Stress Index	moderate	low	low	moderate
Production System	Crop-livestock	Livestock	Livestock	Crop-livestock
Saltland pasture	Saltbush & mixed annual	TWG	Puccinellea & balansa	TWG, mixed annual
Other pastures	Mixed annual, Lucerne	Perennial rye, Mixed annual	TWG, Lucerne	Perennial rye & mixed annual, Phalaris, Lucerne
Establishment cost	$300/ha	$350/ha	$250/ha	$570/ha
Life of saltland pasture (years)	20 years	20 years	15years	15 years

Table 4: Maximum growth rate of saltland pasture of each region (kg of dry matter per hectare per day)

Period	Central Wheatbelt		South West Vic		Upper South East	Central West	
	Saltbush	U.storey	Class 1	Class 2		Control	TWG
1	3.3	6	30	18	15	10	15
2	2.1	6	23	14	22	5	5
3	2.1	7	13	8	32	10	10
4	2.1	29	35	21	57	20	15
5	2.5	45	57	34	31	20	25
6	2.5	-	30	18	-	15	35
7	3.1	-	18	11	-	15	15
8	3.3	-	30	18	-	10	10
9	3.3	-	8	5	-	10	10
10	3.3	-	8	5	-	10	20

Table 5: Energy content of saltland pastures for each region (MJ of energy per kg of dry matter)

Period	Central Wheatbelt		South West Vic		Upper South East	Central West	
	Saltbush	U.storey	Class 1	Class 2		Control	TWG
1	7.8	11.8	11.8	11.8	10.9	8.5	8.0
2	7.8	11.8	12.5	12.5	11.1	9	8.0
3	7.8	11.8	13.3	12.5	11.4	8.5	8.5
4	7.8	11.8	13.3	12.5	11.4	8	9.0
5	7.8	11.3	13.3	12.5	10.9	8	9.5
6	7.8	10.2	8.6	8.9	9.6	7	9.5
7	7.8	8.9	8.6	8.9	8.7	7	9.0
8	7.8	7.4	8.6	8.9	7.7	7.5	9.5
9	7.8	6.8	8.6	8.9	7.0	7.5	9.0
10	7.8	6.2	8.6	8.9	7.0	7.5	8.0

Analysis

The analysis assessed the profitability of experimental treatments imposed saltland pasture on the different research sites. Differences in the range of suitable species for the different environments, the state of knowledge of production from saltland pastures and the interests of farmers in the regions led to each research site imposing different treatments

The Victorian site examined the role of tall wheat grass based pastures, sown into saltland with differing levels of salinity. The analysis for this site was aimed at estimated the profitability of tall wheat grass pasture on mildly (Class 1) and moderately (Class 2) affected saltland.

The Upper South East region of SA focussed research on improving puccinellea based pastures by introducing balansa clover or by applying nitrogen fertiliser. The economic analysis undertaken for this study estimated the benefits of these two treatment compared to an unimproved puccinellea pasture.

The WA site analysis condensed research data from three different sites to explores the benefits of establishing saltbush pasture with an annual understorey compared to volunteer saltland pasture.

The Central West Slopes analysis compared the benefits of improving production of mildly saline land by introducing a tall wheat based pasture (Treatment), to a volunteer pasture that was fenced to improve grazing management (Experimental control). As no data was available on the production of volunteer pasture in the absence of fencing it was assumed to be zero.

Further information on the experiments conducted on each site is available in the Site Reports for this Program.

The four models were used to conduct ‘experiments’ by varying parameter values and production constraints to reflect different production and economic conditions within each of the regions, to determine the effect of each on farm profit.

The ‘experiments’ were designed to determine the influence of the following factors on the profitability of saltland pasture in the four different production environments:

1. Flock type
2. Pasture growth
3. Feed quality
4. Wool and meat prices
5. Cost of pasture establishment
6. Area of saltland on farm
7. Presence of lucerne

Results and Discussion

Profitability of saltland pasture

Table 6 shows the results for each region for the standard assumptions. Summary statistics showing the areas of saltland pasture and pasture unaffected by salinity, total sheep numbers in dry sheep equivalents, stocking rates and supplementary feed are also shown, prior to and post pasture improvement.

Saltland pasture was shown to be profitable in all four study regions for the standard assumptions. The increase in profit resulting from better management and introducing improved plant species was highest for south west Victoria and the Central West of NSW (Table 6). The increase in profit for SA and WA sites was similar although higher for WA with the standard assumptions.

It is important to note that the profitability of the saltland pasture is possibly overstated for the NSW site. No measurements were taken of the growth rate and quality of the volunteer pasture with no management. Anecdotal evidence indicated that there was very little grazing value from the unfenced saltland. The experimental control was volunteer pasture with fencing, to provide some ability to manage grazing. The assessment of economic viability of tall wheat grass pasture should compare the benefit of the experimental treatment to the experimental control, as fencing only provides the next best option to introducing improved pasture species. This comparison is shown in parentheses in Table 6.

Two of the most significant factors affecting farm production in the different environments are growing season rainfall and the length of the growing season. South west Victoria has much higher growing season rainfall and the growing season is over 2 months longer compared to the SA and WA sites (i.e. P1 to P5). Whilst the Central West Slopes has a shorter season compared to south west Victoria, it is much longer compared to the remaining two regions. These two differences have major implications for livestock production, both in terms of the carrying capacity of farms for livestock and requirement for supplementary grain feeding during the drier months when pasture is relatively scarce, as previously discussed.

Table 6: Comparative increases in profit per hectare of saltland, stocking rates and supplementary feed for different scenarios for each of the study regions, prior to pasture improvement and post pasture improvement

Site			Saltland area (ha)	Pasture area (ha)	DSE	Stocking rate (dse/ha)	Supp feed (kg/dse)	Increase in profit ($/ha)
WA	Wool	Prior	200	985	5007	5.1	22	-
		Post	200	915	5559	6.1	25	41
	SR XB	Prior	200	1080	5838	5.4	30	-
		Post	200	1030	6412	6.2	30	61
	XB	Prior	200	1140	6833	6.0	54	-
		Post	200	1150	7411	6.4	48	80
Vic	Class 1	Prior	50	700	11245	16.1	40	-
		Post	50	700	11899	17.0	22	265
	Class 2	Prior	50	700	10898	15.6	24	-
		Post	50	700	11463	16.4	23	158
SA		Prior	800	2000	13008	6.5	18	-
	P&B	Post	800	2000	16085	8.0	16	51
	P&N	Post	800	2000	16085	8.0	16	2
	P only	Post	800	2000	14850	7.4	15	21
NSW		Prior	20	640	8837	13.8	6	-
	Control	Post	20	660	8966	13.5	7	92
	TWG	Post	20	660	9023	13.6	7	148 (56)
No	*Lucerne*	Prior	20	515	7299	14.1	15	-
	Control	Post	20	525	7272	13.9	15	102
	TWG	Post	20	545	7520	13.8	14	227 (125)

Wool – wool only flock
SR XB – cross bred lambs production, cross bred ewes replaced through breeding
XB – cross bred lamb production, cross bred ewes replaced from off-farm source
Class 1 – low salinity index
Class 2 – moderate salinity index
P&B – puccinellea and balansa
P Only – puccinellea only
Control – volunteer pasture that has been fenced and rotationally grazed
TWG – Tall wheat grass sown in a pasture seed mix and rotationally grazed
DSE – dry sheep equivalent

In south west Victoria the very high benefit of improving production on Class 1 land resulted from an increase in the stocking rate by almost one dry sheep equivalent, across the whole farm. Supplementary grain feeding was also reduced, as tall wheat grass pasture provides good quality feed over the summer-autumn period, with around 140mm of rain falling during the 'dry' periods. In total around 700 dry sheep equivalents are added to the flock, resulting in a total net benefit of over $13,000 or $19 per dry sheep equivalent.

Class 2 saltland, has a higher level of salinity and therefore less productive. Moreover the relative increase in feed value of improved species on this land unit is less compared to Class 1. The digestibility of volunteer pasture on the Class 2 land unit is one to two percentage points higher in the growing season compared to tall wheat grass, and up to six percentage points higher during the summer and autumn months. However, there is a net benefit of establishing tall wheat grass on Class 2 land because the much improved growth rate more than compensates for its lower quality.

Despite the lower feed value the net benefits of establishing tall wheat grass on Class 2 land is substantial. The increase in profit is achieved by increasing the stocking rate (whole farm), however the level of supplementary feed is not reduced to the same extent as it is when tall wheat grass is established on Class 1 land.

In the Central West of NSW the optimum stocking rate was also high prior to intervention on saltland (Table 6). Interestingly, the stocking rate, pasture area and rate of supplementary grain feeding did not change as a result of improving the quality and growth rate by introducing improved plant species, which was predominantly tall wheat grass. The benefit accruing to improved saltland pasture was simply a consequence of being able to add more livestock to the farm enterprise. A comparison of results of the unimproved pasture (the control) and the situation prior to intervention (no feed value) reveal a similar change to the optimum farm enterprise mix. That is the stocking rate and rate of supplementary feeding was not altered but stock numbers increased.

In contrast the shorter growing seasons in WA and SA, in addition to much lower rainfall, lead to much lower optimum stocking rates. Whilst stocking rate could be increased by feeding greater quantities of supplementary grain in both regions, the cost of carrying an additional sheep over the period of relative pasture scarcity is much greater compared to the south-west of Victoria.

Coincidently the increase in stocking rate is similar on all sites but the Central West Slopes, when comparing wool only flocks, even though there is a large difference in the increase in profit per hectare of saltland pasture. On face value this is a contradiction as one might expect that similar changes in stocking rate would lead to similar changes in profitability. However the increase in stocking rate for the Victorian site is also accompanied by a large decrease in the rate of supplementary grain feeding. Also the benefit of saltland pasture is the quotient of whole farm profit and area of saltland. Whilst the increase in whole farm profit is highest for the SA site, the area of salinity is proportionally much smaller for the Victorian site.

The increase in stocking rate and in some cases supplementary feeding, may have implications for the extension and adoption of improved saltland pasture. Generally the benefits of improved pasture accrue as a result of increasing intensity of production and this may be an impediment to adoption for some farmers. For example, in the current economic climate additional labour is difficult to acquire and farmers may be unwilling to work longer hours. Furthermore increased production intensity may require additional management flexibility to adjust farm strategy to cope with weather variation.

Achieving productivity gains

Another important feature of the results (Table 6) is that there is no consistent pattern between sites in the changes in management that are selected by the models to maximise whole farm profit (Table 6). In some instances profit is increased simply by increasing stocking rate of the representative farm (SA site). In others the stocking rate is increased and the level of supplementary feed per dry sheep equivalent is reduced simultaneously (Victorian site). The results from the Central West Slopes model indicated that the best strategy for utilising additional feed provided by tall wheat grass was to add livestock by an amount proportional to the increase in the feed value of the improved pasture.

Other results were much less intuitive. On the Central Wheatbelt representative farm productivity was improved by *reducing* the area of pasture and increasing the crop area. Saltland pasture provided the capacity to decrease the pasture area on the rest of the farm and yet increase livestock numbers. Part of the profit increase, therefore is attributable to increased crop production.

Indeed it is possible that increasing pasture productivity could improve profit at the same time as stocking rates are reduced This has been shown in at least one study that examined the role of new pasture species in the Central Wheatbelt of WA (Bathgate *et al*, in progess). New pasture species improved the profitability of pasture sufficiently for the area of pasture to be increased on land that had a low livestock carrying capacity compared to areas of land that were previously established to pasture. This had the effect of reducing the average stocking rate across the whole farm. This situation will more likely occur on mixed farming systems with heterogeneous soils where there are differences in the relative production of crop and pasture.

This result highlights a potential limitation of partial analysis, particularly those that focus mainly on the potential to increase stocking rate. That is, it is possible to make a range of adjustments to enterprise mix and farm strategy to take advantage of additional pasture growth provided by improved management or new species. Increasing stocking rate alone may not be the best strategy and analyses that focus on this may lead to the benefits being incorrectly estimated.

Flock type

The flock structure had a significant effect on the farm profit in two of the regions (Figures 5a & 5d). At the standard meat and wool prices, prime lamb production is the most profitable livestock enterprise for WA and NSW sites, compared to merino prime lamb and wool production. No results are shown for the Victorian site or the SA site. The genotype of sheep assumed in the Victorian model is not well suited to prime lamb production. The smaller size of the assumed genotype limits the growth rate of lambs, constraining the ability of farmers to achieve required liveweight. In the Upper South East of SA there are practical difficulties associated with prime lamb production.

In the WA and NSW region saltland pasture improves the profitability of prime lamb production to a greater extent compared to other flock structures. In the Central Wheatbelt the increased availability of feed over summer and autumn enables the stocking rate to be increased without increasing the rate of supplementary feeding per head. However the total grain fed is higher. This is consistent with another study (Bathgate, Unpublished) that also examined the effect of stocking rate on the profitability of prime lamb in the same region. Where stocking rate was not increased prime lamb production was much less profitable compared to the results of this study, and much similar to the profitability of a wool only flock.

Prime lamb production also improved the profitability of saltland pasture in the Central West (Figure 5d), however the stocking rate and rate of supplementary feeding were not altered significantly. Stock numbers were however increased which was made possible by improving the feed value of pasture on saltland and by substituting some of the crop area with pasture.

Pasture growth rate

The growth rate of saltland pasture, and hence the availability of feed for livestock, is a major influence on the profitability of establishing pasture on salt affected land (Figures 4a-d). This finding is consistent with a number of other studies that have shown the affect of improved pasture production on the profitability of saltbush (eg Bathgate *et al*, 1992, Barrett-Lennard *et al* 2003 and O'Connell *et al*, 2006).

Reductions in the growth rate of improved saltland pasture led to proportionally greater reductions in benefits on all sites except Victoria (Figures 4a-4d). Reductions of 20% (WA) and 10% (SA and NSW) lead to a decline in benefits of improving saltland pasture below $30 per hectare of saltland. Below this level of benefit the incentive for farmers to establish pasture on saltland will be significantly diminished and widespread adoption less likely.

As previously discussed assessing the profitability of saltland pasture requires a comparison with the next best alternative. Therefore, whilst results show that tall wheat pasture on the NSW sites improves returns substantially over the 'do nothing' option, the net return to tall wheat grass establishment is the difference between the treatment and control curves (Figure 4d). The difference between these curves is less than $30 per hectare when the relative production of tall wheat grass drops below 90% of the assumed growth rates.

Reductions in pasture growth have much less effect on the benefits of tall wheat grass pasture on the Victorian model farm, at least in terms of the proportional change in profit. Extrapolating the line in Figure 4b shows that a reduction in pasture growth rate of 60% would be required on Class 2 land and greater than 80% on Class 1 land to reduce profits to around $30 per hectare.

Pasture Quality

The quality of the pasture on saltland had a major influence on its profitability. Figures 5b, 5c and 5d show that reductions in digestibility have a proportionally much greater impact on farm profit compared to a similar percentage change in growth rate. This is not a surprising result as pasture quality is a major determinant of feed value and thus livestock production. Lower dry matter digestibility of a few percentage points (1.5 pp in SA and 6 pp in Victoria) is sufficient to render improved pastures economically unviable on all sites except WA.

Quality is a seemingly less important influence in the WA model farm. However, this requires a qualification. The focus of the WA analysis was specifically on the value of saltbush, whereas saltland pasture being researched and promoted in this region has an understorey component that is a significant contributor to pasture biomass. Therefore the affect of reduced quality in the saltbush component is ‘buffered’ by the availability of the understorey.

The impact of quality on the profitability of saltlland pasture has implications for management, as the quality of perennial species is greatly influenced by grazing management. Long periods of deferment will lead to a decline in quality, thus affecting the feed value to sheep when grazed. However the quality assumed in this analysis implies short deferment periods during the growing season and no deferment over the drier months.

On some farms it may be practically difficult to undertake the level of management required to maintain pasture quality at the levels assumed in this analysis. Where this is the case the profitability of saltland pasture will be much lower compared to the results of this study.

Wool and lamb Prices

Wool and lamb prices have a a significant impact on the profitability of improved pastures on saltland (Figures 6a-d). This demonstrates that product prices will influence farmers’ incentive to improve the management of saltland. However the viability of improved pasture was adversely affected on only one site. . Wool prices below a market indicator of 650 cents per kilogram reduced the profitability of puccinellea/balansa pasture to less than $30 per hectare. On all other sites the wool price would need to drop well below 500 cents per kilogram to threaten the viability of improving saltland pasture. The only exception to this is where low wool prices are accompanied by very low prime lamb prices on the WA site.

There is an apparent contradiction in these results, given the value of improved puccinellea pasture is of similar value of pasture improvement on the NSW and WA sites. Wool price has less effect on the viability of pasture improvement on these two sites. Low wool prices have a larger effect on viability in the Upper South East region because the increase in stocking rate is achieved at a much greater cost. A much larger area of saltland pasture is required to increase the stocking rate by between 1-1.5 dse per hectare and therefore establishment costs are much higher proportion of the increase in total revenue. Therefore a given percentage reduction in total revenue brought about by a lower wool price will have a greater impact on net revenue.

Establishment cost

At the standard price and production assumptions the profitability of improved saltland pasture is not very sensitive to the cost of establishment. At a real interest rate of 5% per annum a $50 per hectare change in the costs of establishment will alter the amortised cost by $4.82 per hectare, assuming that the pasture needs to be re-established every 15 years. This decreases to $4.01 per hectare if re-establishment is required only every 20 years. Therefore very large increases in the establishment cost would be required to adversely affect the viability of improved saltland pasture. The SA and WA sites would be most affected by increased costs, (eg as would occur if pasture failed to establish) given the relatively small increase in profit, compared to the NSW and Victorian sites.

Whilst the profitability of saltlland pasture is not very sensitive to changes in the establishment costs it is important to note that a requirement for large initial outlays may act as a disincentive for farmers to adopt improved pasture species. The is especially pertinent in recent times where cashflows of farm businesses have been very low.

Area of saltland

Figures 7a-d show the effect of the area of saltland on the net benefits of improving pasture growth and quality. The figures show two contrasting sets of results. The per hectare benefit of improving pasture on saltland decreases as the area increases on the WA and Victorian sites, while the net benefit per hectare on the other two sites increases then decreases with area.

This was not expected as saltland pasture does not provide a uniform increase in the supply of feed throughout the year. Therefore it might be anticipated as the area of saltland increases a feed shortage would be created during periods when saltland pasture is in low supply.

It is important to note that the figures show the per hectare benefit of improving saltland pasture, not whole farm profit. For each model farm profit declines as the area of salt increases however the difference in the profitability of improved versus unimproved increases with the area of saltland.

These results can be partly explained by examining the difference in stocking rate between improved and unimproved pasture and the difference in the level of supplementary feeding. These results are shown in Table 7.

Tabel 7 shows that the stocking rate selected by all models is higher with improved pasture, and this difference increases with area of saltland. For instance when the total area of salt is 150 hectares for the SA site improved pasture has a stocking rate that is 0.3 dse per hectare higher compared to unimproved pasture., while at 1350 hectares of saltland the stocking rate is 3.3 dry sheep equivalents per hectare higher. This trend is consistent across all sites.

Table 7: Difference in stocking rates and levels of supplementary feeding for improved and unimproved saltland pasture

Site	Area of saltland (ha)	Supp feeding (kg per dse)	Stocking rate (dse per ha)
SA	150	-0.6	0.3
	1350	-5.1	3.3
NSW	50	-0.3	0.2
	440	-4	3.7
Vic	50	0	1.1
	290	0.3	5.2
WA	50	-1.8	0.5
	600	7.7	3.9

A comparison of the levels of supplementary feeding however, show that the grain fed per dse is lower for improved pasture on all but one site a the smallest area of saltland. Moreover the levels of grain feeding decline further as the salt area increase on the SA and NSW sites, where the benefit of improved pasture increases with area of of saltland (Figures 7c&d). The sites for which the per hectare benefits of improved pasture decline show an increase in the level of supplementary feeding per dry sheep equivalent (Figure 7a & b). This provides a good indication that a feed shortage is being encountered and the model is opting to increase grain feeding to redress this constraint. However this comes at a substantial cost, such that the per hectare benefit of improving pasture on saltland declines with increasing area.

Role of lucerne

Table 1 shows the influence of lucerne on the profitability of saltland pasture. Many farms in the Central West Slope do not have suitable soils for lucerne production, and therefore have less access to high quality feed between P6 and P10. In this situation the results indicate there would be a marked increase in the benefits of saltland pasture in the absence of lucerne. Whilst the optimum stocking rate is similar there is a doubling of the level of supplementary feeding. The increase in profit demonstrates that there is a degree of substitution between lucerne and saltland pasture, but not sufficient to render saltland pasture unprofitable. There is also substitution between grain feeding and lucerne, but very little between saltland pasture and grain feeding.

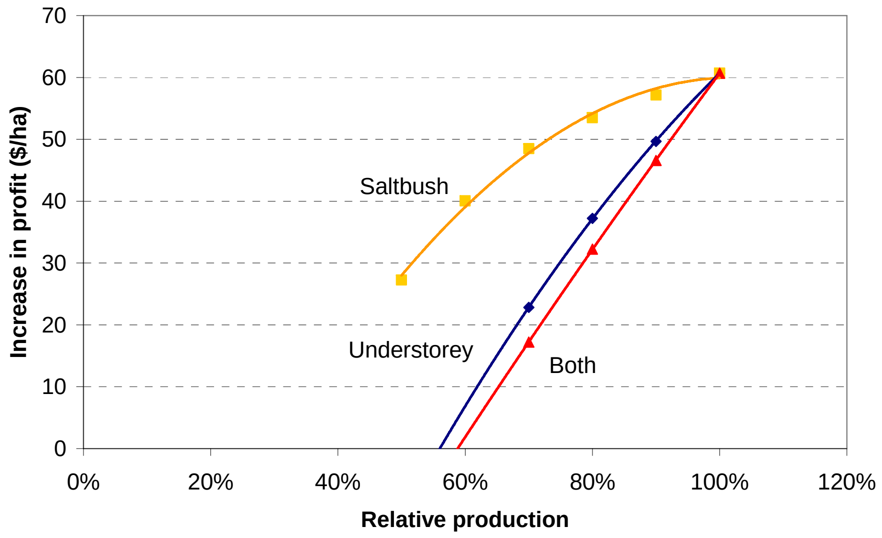

Figure 4a: Increase in profit per hectare resulting from saltland pasture at different production levels for the Central Wheatbelt of WA

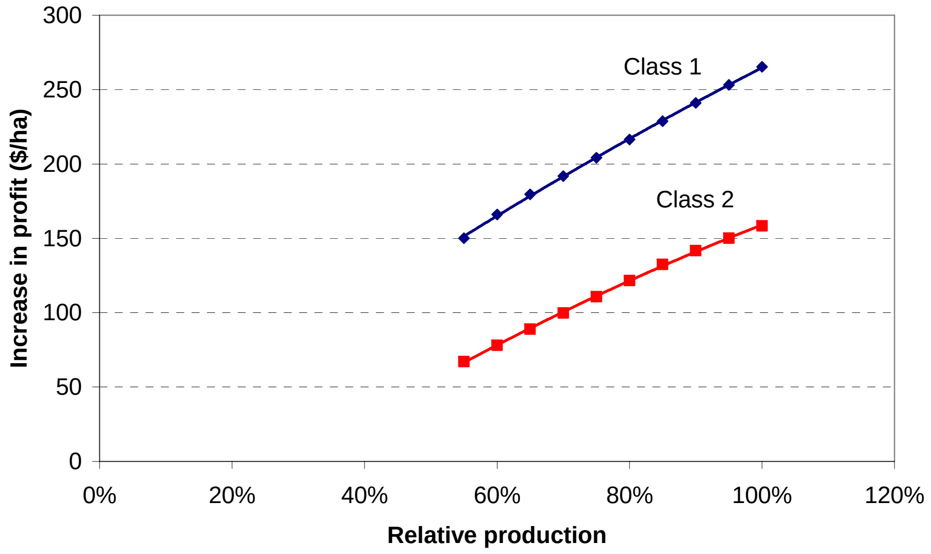

Figure 4b: Increase in profit per hectare resulting from saltland pasture at different production levels for south west Victoria

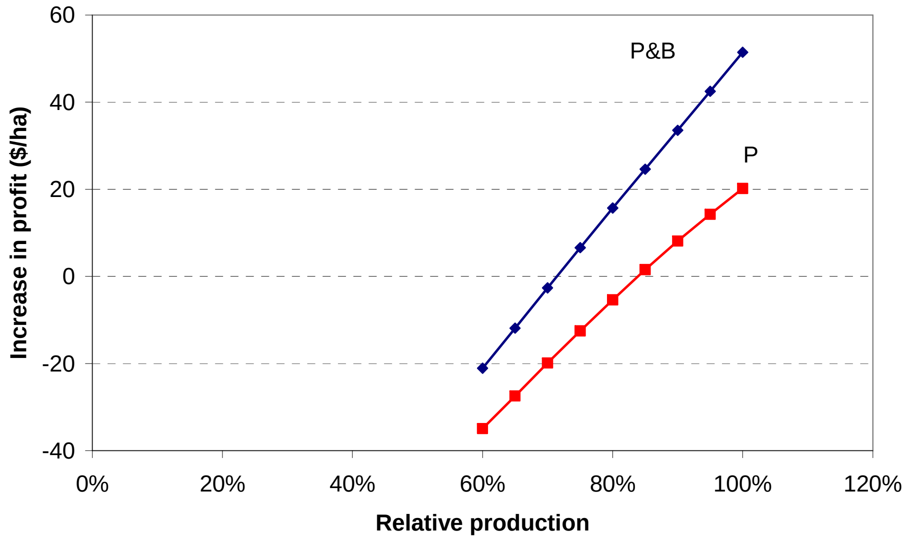

Figure 4c: Increase in profit per hectare resulting from saltland pasture at different production level for the Upper South East of SA.

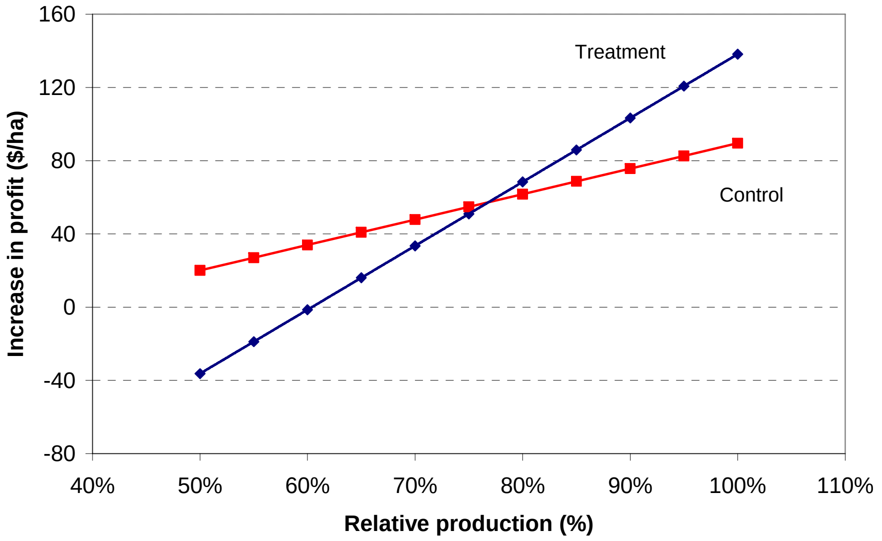

Figure 4d: Increase in profit per hectare from resulting from saltland pasture at different production levels for the Central West of NSW

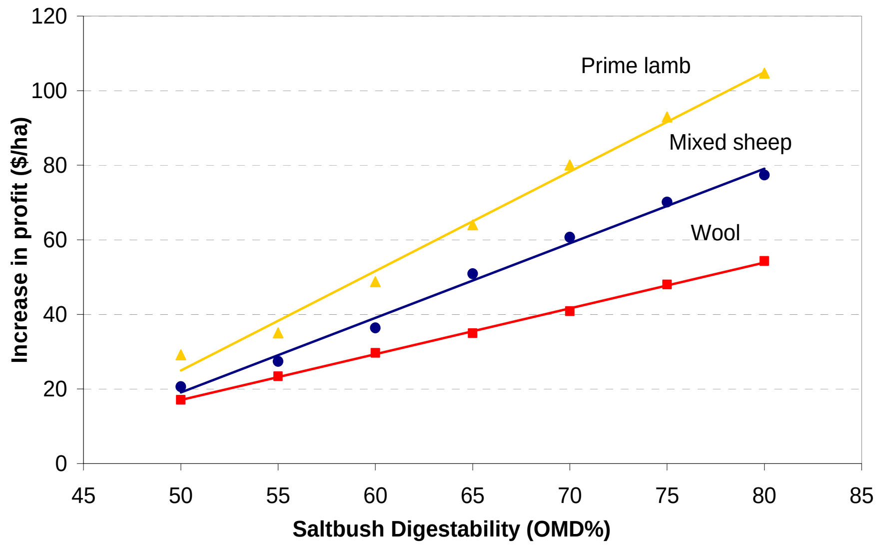

Figure 5a: Increase in profit per hectare resulting from saltland pasture at different pasture quality levels for the Central Wheatbelt of WA

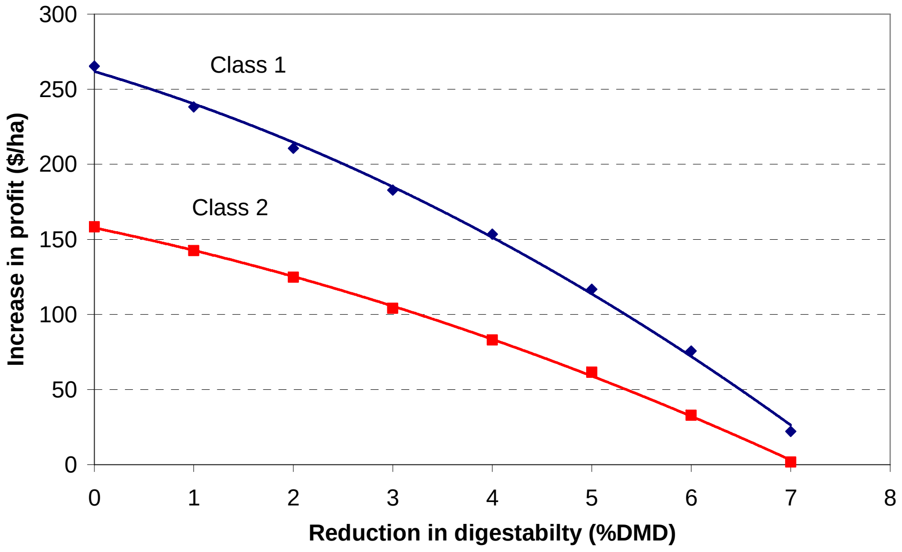

Figure 5b: Increase in profit per hectare resulting from saltland pasture at different pasture quality for south west Victoria

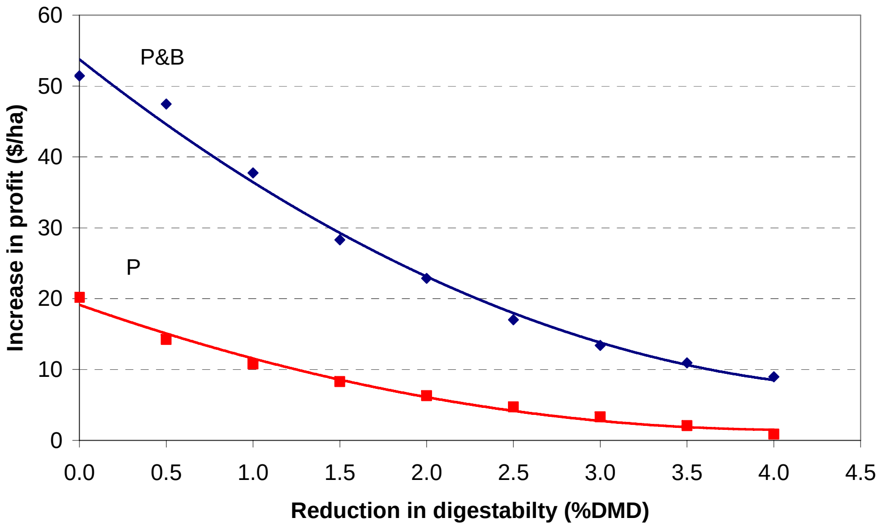

Figure 5c: Increase in profit per hectare resulting from saltland pasture at different production level for the Upper South East of SA.

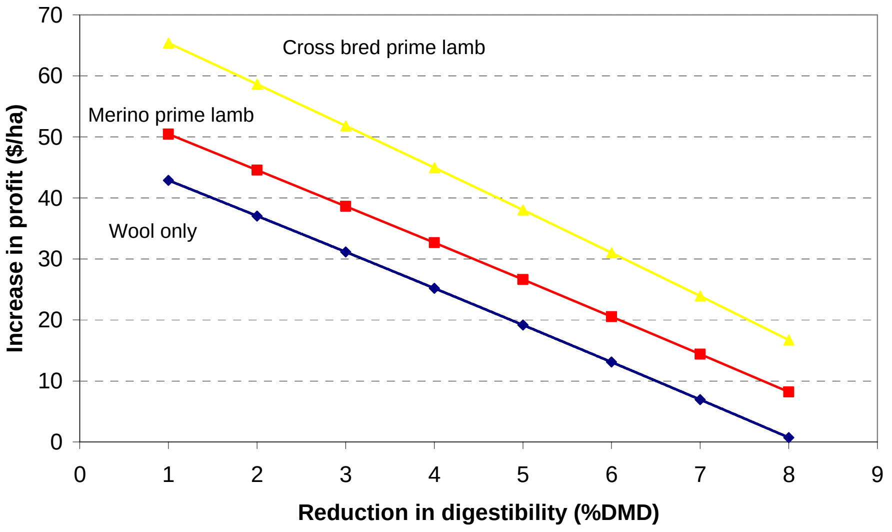

Figure 5d: Increase in profit per hectare resulting from saltland pasture at different production level for the Central West of NSW.

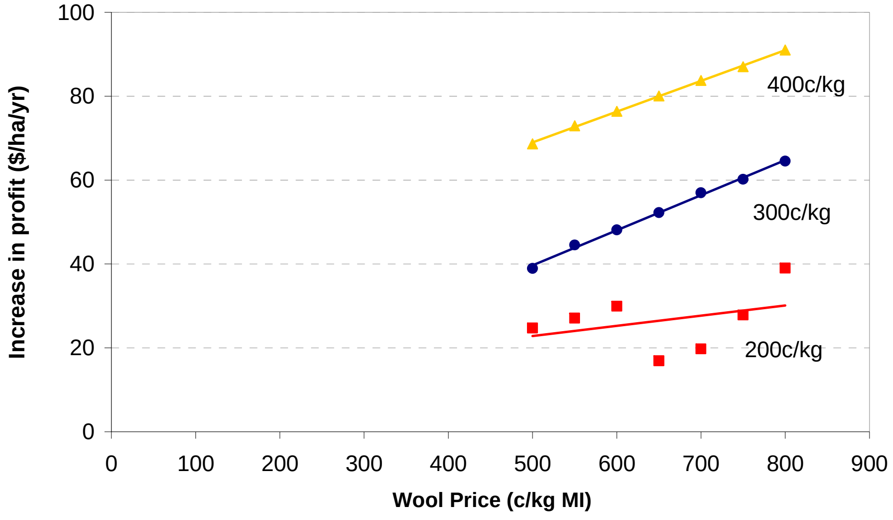

Figure 6a: Increase in profit per hectare resulting from saltland pasture at wool prices for the Central Wheatbelt of WA.

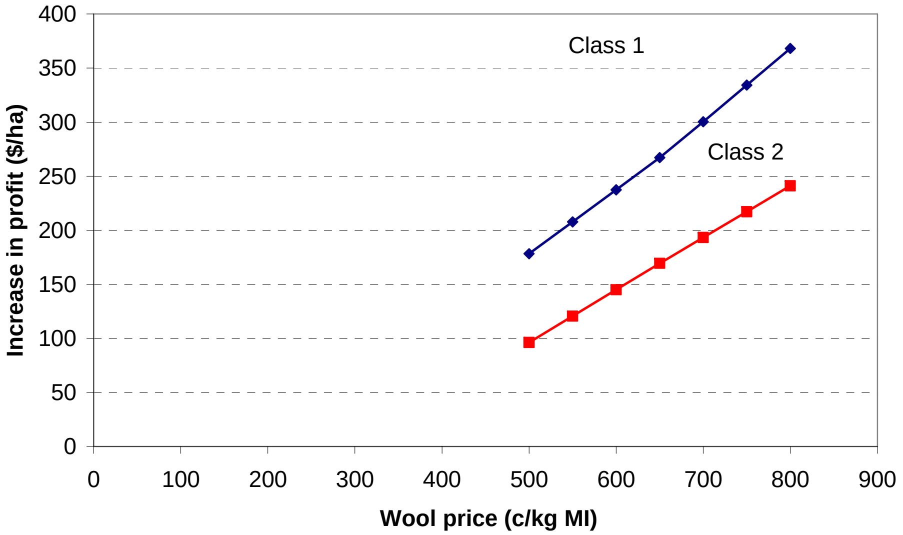

Figure 6b: Increase in profit per hectare resulting from saltland pasture at different wool prices for south west Victoria.

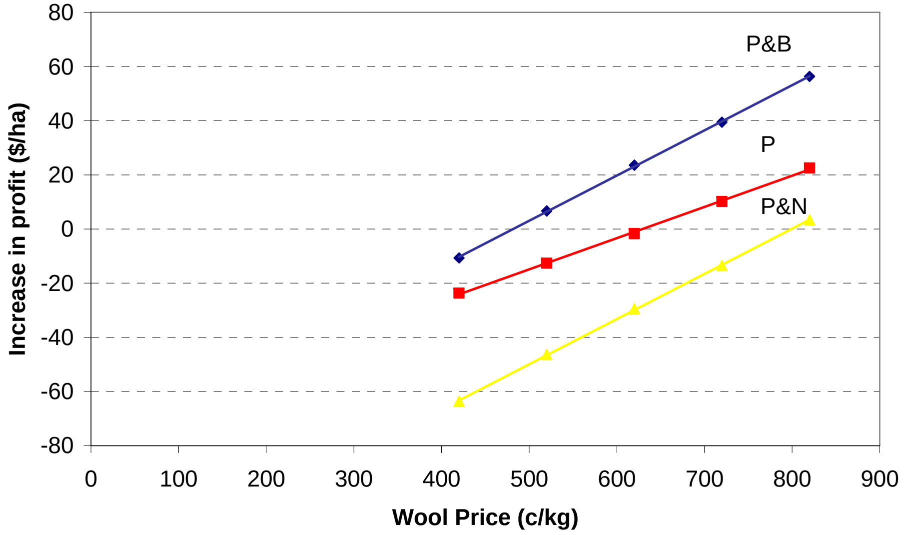

Figure 6c: Increase in profit per hectare resulting from saltland pasture at different production level for the Upper South East of SA.

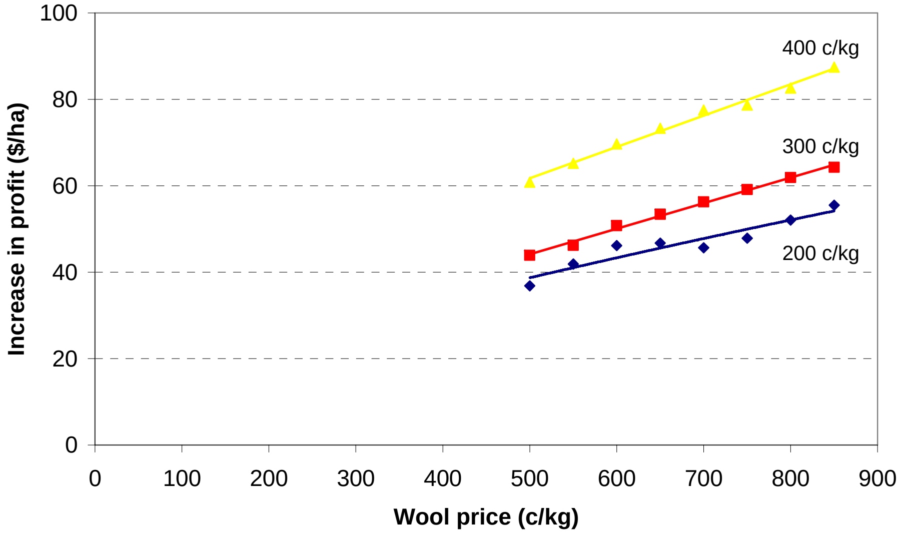

Figure 6d: Increase in profit per hectare resulting from saltland pasture at different production level for the Central West of NSW.

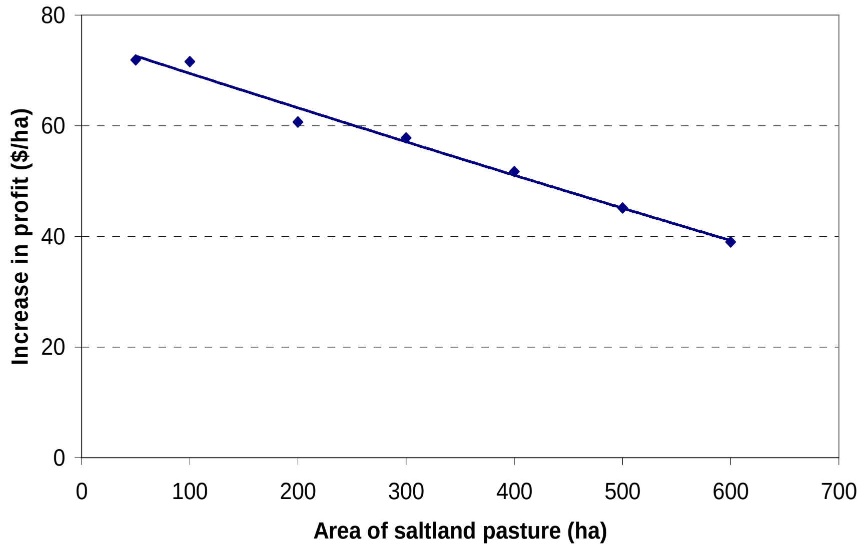

Figure 7a: Increase in profit per hectare resulting from saltland pasture at different areas of saltland for the Central Wheatbelt of WA

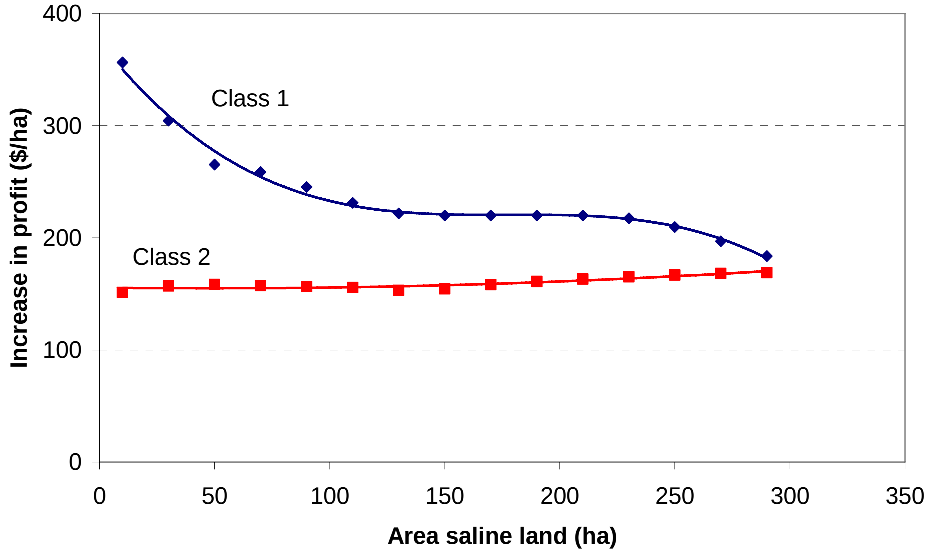

Figure 7b: Increase in profit per hectare resulting from saltland pasture at different areas of saltland for the south west Victoria.

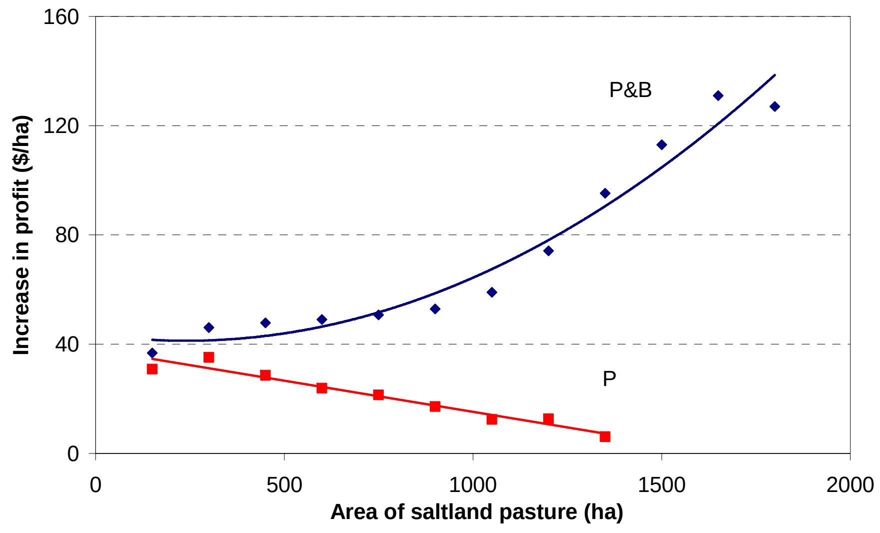

Figure 7c: Increase in profit per hectare resulting from saltland pasture at different areas of saltland for the Upper South East of SA

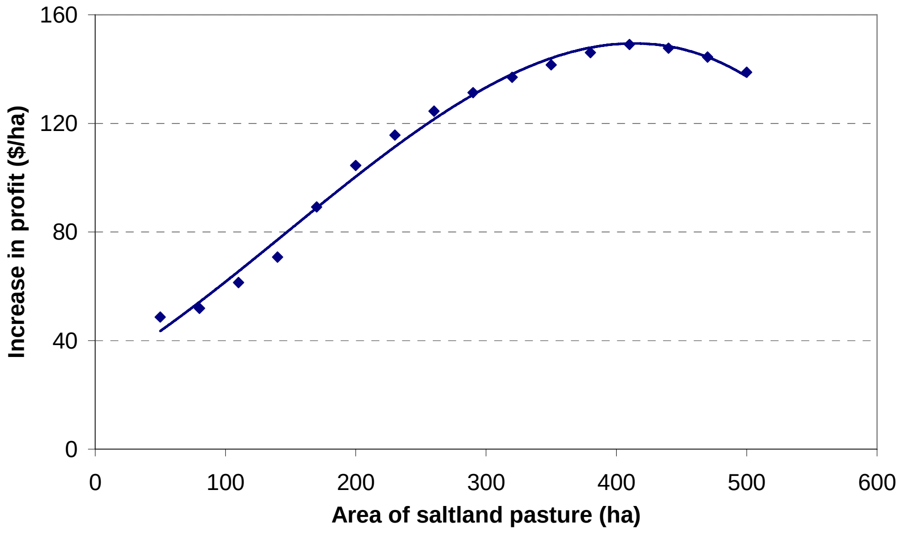

Figure 7d: Increase in profit per hectare resulting from saltland pasture at different areas of saltland for the Central West of NSW.

Conclusions

Introducing improved pasture species to salt affected land to increase the feed value for livestock is profitable across a broad range of environments, production conditions and commodity price assumptions.

The extent to which farmers can achieve the increases in profit suggested by this study will depend critically on their ability to manage the livestock enterprise to achieve the pasture production levels assumed. Pasture quality and growth were shown to have a major effect on the profitability of improved pastures. Maintaining pasture quality of perennial species requires good grazing management, as long periods of deferment will lead to substantial reductions in feed value. The models used in this study typically selected high stocking rates to increase farm profit when improved pastures on saltland were introduced. This was accompanied by increases in the amount of supplementary feeding in some cases.

It was generally the case that higher farm profit was achieved by increasing the intensity of production. This has potential implications for adoption of improved saltland pastures and consequently for extension; namely that factors that may limit the ability of farmers to increase intensity of production need to be understood and addressed if widespread adoption is likely to occur.

More analysis is required to improve understanding of the economic the impact of the production environment on the profitability of improved saltland pasture. However the results indicated that the benefits were higher where growing season was longer and summer growth rates were higher.

The benefits of improving saltland pasture were relatively insensitive to establishment costs. However large initial outlays to establish improved pasture may in itself be an impediment to broad scale adoption, particularly during periods of low cashflow such has occurred over the past 4-5 years in the Eastern States of Australia.

Saltland pasture was shown to be generally more profitable for a prime lamb enterprise, where this was a profitable option for farmers, in the absence of saltland pasture. Saltland pasture was also shown to be more profitable where lucerne production was not a viable option.

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