

Achieving profitable and environmentally beneficial grazing systems for saline land in Australia

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SUMMARY – This paper reports some of the findings from a 4 year multidisciplinary on-farm study examining *Atriplex* (saltbush) based pastures growing on land affected by secondary salinity for biomass growth and nutritive value, plant agronomy, sheep production, whole-farm economics, hydrology and biodiversity. Our aim was to develop options for livestock production from saline land that are profitable and reduce negative environmental and social impacts from salinisation. We found that revegetation of saline land with saltbushes and annual legumes has the potential to quadruple animal carrying capacity during the autumn, lessening the impact of relatively poor seasons and reduce moisture within soil profiles leading to slower groundwater recharge. Revegetation of the saline parts of a farm increased profits however economic returns decreased as the degree of salinity increased. The outcomes from this study are exciting as they suggest that profitability and positive environmental outcomes can be achieved concurrently and strongly support the use of on-farm multidisciplinary research approaches for the development of new grazing systems in marginal landscapes.

Keywords: *Atriplex*, groundwater, perennials, salinity, saltbush, sheep.

RESUME – "Mise en place de systèmes de pâturage rentables et bénéfiques pour l'environnement dans des terrains salins en Australie". Cet article présente les conclusions d'une étude multidisciplinaire d'une durée de quatre ans et qui a eu lieu dans une ferme. Le but était d'analyser les pâturages *Atriplex* qui poussent sur des terrains touchés par une salinité secondaire. On a également analysé l'expansion de la biomasse et la valeur nutritive, l'agronomie des plantes, l'élevage des moutons, l'économie de la ferme entière, l'hydrologie et la biodiversité. Notre but était de mettre au point des alternatives pour la production de bétail sur des terrains salins, qui puissent être rentables et en même temps réduire les effets négatifs de la salinisation sur l'environnement et la communauté. On a conclu que la re-végétation de terrains salins avec de l'*Atriplex* et des légumineuses annuelles a le potentiel de quadrupler la capacité d'élevage de bétail dans ces régions durant la saison d'automne quand il y a une interruption de nourriture, de servir de solution tampon pendant les mauvaises saisons de production agricole et de réduire l'humidité dans le profil du sol et en conséquence ralentir la recharge de la nappe phréatique. La re-végétation des terrains agricoles salins a augmenté les bénéfices, cependant la rentabilité économique a diminué avec l'augmentation du degré de salinité. Les conclusions de cette étude sont saisissantes parce qu'elles suggèrent que la rentabilité et les conséquences positives pour l'environnement peuvent être réalisées simultanément et sont favorables aux démarches de recherches multidisciplinaires dans une ferme.

Mots-clés : *Atriplex*, nappe phréatique, plantes pluriannuelles, salinité, moutons.

Introduction

Dryland salinity is a major threat to agriculture in southern Australia. In the state of Western Australia (WA) alone it is now believed that there are between 1.0 and 1.2 million ha of severely salinised land and between 2.8 and 4.4 million ha of land with a high hazard of secondary salinity (Macfarlane *et al.*, 2004). The Australian Bureau of Statistics estimates that 51% of farms in WA are affected by salinity. One of the few commercial production opportunities for saline land in the low to medium rainfall zones (300-450 mm/year) of WA is the production of saltbush for grazing by sheep. Saltbushes and other halophytic chenopods such as bluebushes (*Mariana* spp.) are planted on an estimated 30,000 ha of saline and waterlogged soils in the low to medium rainfall mixed crop and livestock zone. Factors that are likely to drive profitability and sustainability of saltbush-based pasture systems include biomass production, feeding value of the biomass, time of feed availability, integration within the farming system, water use and environmental stability. The aim of this research project was to investigate options for livestock production from saltbush-based pasture systems that are profitable and reduce the negative environmental and social impacts from saline land. To

maximise our understanding of these systems, a multidisciplinary approach was undertaken involving host farmers, economists, hydrologists, animal nutritionists, agronomists and ecologists.

Materials and methods

The research was conducted on two mixed enterprise (sheep and cereal cropping) farms in WA, near the towns of Tammin and Yealering, however, only data from the Yealering site is presented in this paper. This 3000 ha property is situated 250 km south-east of Perth (32.60° S, 117.62° E) in a Mediterranean climate zone with an average of 350 mm annual rainfall. The land was cleared of native perennial vegetation in the early 1900's and evidence of dryland salinity in the valley floors became apparent during the 1970's.

The 52 ha research site was subject to a calibrated (through soil cores) electromagnetic survey (using EM38 and EM31 instruments) to estimate the salt storage and a digital elevation model. The top 1.5 m of soil contained an average of 99 kg of salt/m² and the water table averaged 1.1 m depth. The groundwater had an average electrical conductivity of 2600 mS/m and a pH of 4. After consideration of the site characterisation data, the site was divided into 2 x 26 ha paddocks. To monitor surface runoff of water and transported salt, a trapezoidal flume was installed in each paddock, with bund walls installed to isolate each paddock from external surface flows, and to guide all surface flow from the paddocks through the flumes. The volume and salinity of water leaving the paddocks through the flumes was monitored continuously from autumn 2003. Piezometers and neutron access tubes were installed across the site to assess movement of salt and water through the soil profile and meteorological stations were installed in each paddock to measure rainfall and temperature.

The paddocks were monitored for a year, including grazing in autumn 2004, before one paddock ("improved") was revegetated with a saltbush-based pasture in winter 2004. Saltbush seedlings (mixed *A. amnicola* and *A. nummularia*) were planted in double rows, spaced 10m apart, at a density of 600 stems/ha. A mixture of understorey species consisting of *Medicago polymorpha*, *M. truncatula*, *Trifolium michelianum*, *T. resupinatum*, *T. subterraneum* and *T. glanduliferum* was sown between the saltbush rows. The unmodified paddock ("unimproved") contained 95% sea barley grass (*Hordeum marinum*). Plant composition and dry matter (DM) production were quantified in spring each year as well as immediately prior to and after grazing in autumn. Saltbush edible DM (leaves and small stems with a diameter of < 3mm) was estimated using the "Adelaide technique of Andrew *et al.*, (1979).

In January 2006, both of the paddocks were divided equally into 4 smaller plots for grazing measurements. Grazing with 8 month old Merino wethers, at a stocking rates ranging from 5 to 15 sheep/ha, occurred in autumn 2006 and 2007. Liveweight and condition score were monitored every 7-21 days for up to 80 days and grazing was terminated for all plots when sheep were losing significant weight and condition. Sheep had access to unlimited fresh drinking water at all times during grazing. As the initial liveweight of weaner sheep used in this experiment varied between years, the grazing days that are presented in this paper have been standardised. The standardisation was conducted using the ruminant nutrition model GrazFeed (Freer *et al.*, 1997) to predict the energy (MJ/sheep/day) that was required from the pasture to achieve the recorded liveweight change for the liveweight and age of sheep that were used. The energy per hectare that was obtained from the pasture was then divided by 8.8 which is the expected energy maintenance requirement of a 50 kg mature Merino wethers grazing 10 MJ of metabolisable energy per kg of DM. Grazing days per ha adjusted to represent a mature wether are referred to in the text as "ME adj. GD".

Economic analyses were completed using the central wheatbelt version of MIDAS (Model of an Integrated Dryland Agricultural System). MIDAS is a whole-farm optimisation model that jointly emphasizes the biology and economics of farming systems. MIDAS describes a representative farm for a particular region, with associated production inputs and outputs for a "typical" rainfall year. The model assumes a farm size of 2000 hectares of which 10%, or 200 hectares, is salt-affected. The model selects the set of farm activities which will maximise farm profit, subject to managerial, resource and environmental constraints. Interactions between different enterprises are included in the model and past analysis has shown that interactions play an important role in the selection of optimum strategies. MIDAS compares two production states, in this case with and without improved saltland pasture, but does not account for the transition from one state to another.

Results and discussion

Animal performance and economic returns

Planting saltbush seedlings and sowing a mixture of annual legumes led to higher animal production over two years. During autumn 2006 and autumn 2007, the saltbush and sown understorey plots supported 3 to 4.5 times more grazing days for sheep ($p < 0.001$, both years). This difference was achieved through higher understorey biomass production with a significant legume component and the additional saltbush biomass (Table 1). While the saltbush had energy levels below the maintenance requirement for the sheep (mean digestible organic matter in the dry matter 52 %), it contained high crude protein (mean 13.5 %) and a range of essential vitamins and minerals.

Table 1. Mean understorey and saltbush biomass production and grazing days per ha from unimproved saline land and an adjacent (improved) area planted to annual legumes and saltbush

	Understorey biomass (kg DM/ha)		Edible* saltbush biomass (kg DM/ha)	Grazing days (ME adj. GD/ha**)	
	Unimproved	Improved	Improved	Unimproved	Improved
Autumn 2006	1781 ± 442	3948 ± 665	618 ± 49	409 ± 16.2	1168 ± 52.7
Autumn 2007	1140 ± 180	1479 ± 229	300 ± 40	105 ± 13.4	482 ± 13.2

*The edible component of the shrubs consisted on leaves and stems < 3 mm in diameter.

**Grazing days per ha adjusted to represent the maintenance requirement of 50 kg wethers (see text).

The whole farm economic modelling revealed that revegetation of the mildly saline land on a "typical" farm leads to a 17% increase in whole farm profit. This is achieved through cropping an additional 3% of land (to 49%) and through carrying 10% more sheep. To obtain the benefits the model indicates that the saline land must be grazed in both spring (to maximise use of the legume understorey) and during the autumn feed gap. The model does not account for a range of other benefits such as reduced time spent supplementary feeding in autumn, risk management during poor seasons, visual amenity or environmental outcomes.

Environmental benefits

Three years after establishment, evidence is suggesting that the saltbush and sown understorey offer environmental benefits in the form of increased water use. The mean groundwater levels under the saltbush and sown understorey paddock has declined about 5 cm per year, about twice the rate of the unimproved paddock (Fig. 1). The difference in water table depth is accompanied by reduced moisture content above the watertable (data not presented). A deeper watertable means that plants are less likely to experience waterlogging (leading to reduced growth and death) and salt is less likely to reach the soil surface through capillary rise. It is possible that saltbush-based pastures have the capacity to stabilise saline areas if they are planted before the water table gets too close to the soil surface. This will allow the growth of a legume-based understorey.

Conclusions

Revegetation of mild to moderately saline land in the low to medium rainfall zone of WA offers benefits to producers including increased economic returns from animal production systems and improved environmental health. A range of social benefits were also identified including increased visual amenity and ease of livestock management. The results conclusively show that livestock can be profitably grazed in degraded landscapes and that this production can be accompanied by environmental improvement. The benefits are highly dependent on the selection and design of pasture systems and on the management of grazing pressure. This study highlights necessity of taking a whole systems approach as farmers may be motivated to different degrees by economic and environmental goals.

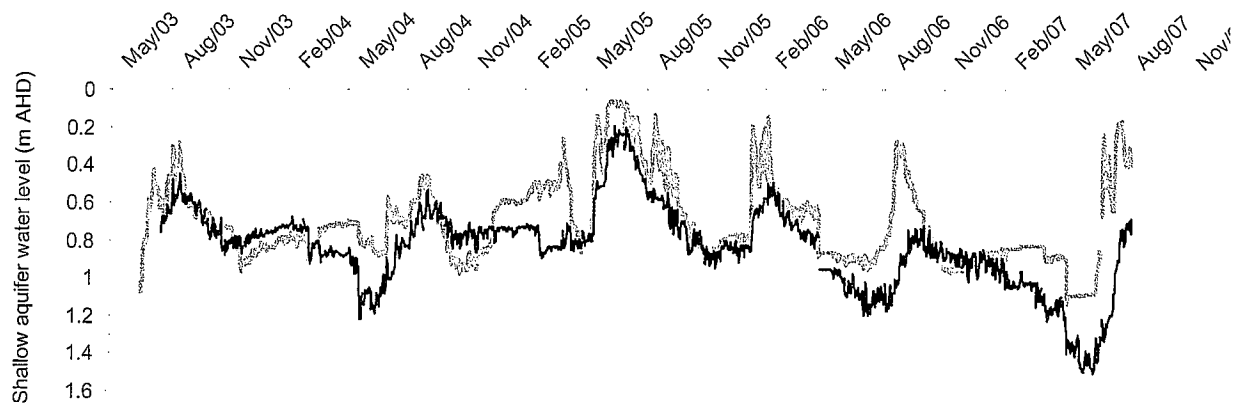


Fig. 1. Groundwater levels under the unimproved (grey) and saltbush with sown understorey (black) at the Yealering research site from May 2003 until November 2007.

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References

- Andrew, M.H., Noble, I.R. and Lange, R.T. (1979). A non-destructive method for estimating the weight of forage on shrubs. *Australian Rangeland Journal*, 1: 225-231.
- Freer, M., Moore, A. D. and Donnelly, J. R. (1997). GRAZPLAN: Decision support systems for Australian enterprises - II. The animal biology model for feed intake, production and reproduction and the GrazFeed DSS. *Agricultural Systems*, 54: 77-126.
- Macfarlane, D.J., George, R.J. and Cacceta, P.A. (2004). The extent and potential area of salt-affected land in Western Australia estimated using remote sensing digital terrain models. In: *Proc 1st national salinity engineering conference*. Perth, Australia, November 2004. Dogramaci, S. and Watehouse, A. (eds) pp. 55-60.



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