

Perennial pastures on saline land can change salt and water balances

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Abstract

In this paper we review the hydrological impacts of salt land grazing systems. Results from previous work are assessed along with those from recent experiments as part of the Sustainable Grazing on Saline Lands program. The new experiments ran from 2003 to 2007, and are the first to quantify the salt and water balances within salt land grazing systems. Cross-site conclusions from this work are that implementing a salt land grazing system based on perennial fodder species raises the evaporative losses from the site, and reduces over-land water flow from the site, both by up to 30%. However, this is not universal, and varies very much from site to site.

Concentration of salts in the surface flows was observed to increase in early years, which may be due to the reduction in water flows off the sites, but total salt export increased substantially. It is presumed that this is due to the better mixing of surface waters with the soil disturbed in the planting operation, and is, hopefully, temporary. A substantial mobilisation of surface soil occurred in the plots sown to new pasture and fodder species leading to top-soil erosion and deposition in the nearby stream channel and at the gauging structures. This may be a temporary effect of the surface disturbance but further data collection will be necessary to confirm this. There is a reduction in waterlogging and in average soil moisture storage above the watertable in the salt land pasture relative to neighbouring un-modified paddocks, and there are clear indications of groundwater use by saltbush under favourable circumstances. Implications of relocation of salts in the root zone on sustainability of the plantings are discussed and the results are discussed in a whole of catchment context.

Introduction

Secondary salinisation of agricultural land in Australia has now reached over 2 Mha (McFarlane *et al.*, 2004). The cause is the replacement of native deep-rooted perennial vegetation with shallow rooted annual species, which use less water than the natives, resulting in greater recharge, and a consequent rise in watertables bringing salts from deep in the profile to the surface. Proposed solutions to the “salinity problem” have been many and varied over many decades (Whittington, 1976, OPUS of the National Dryland Salinity Programme, NDSP). Masters *et al.* (2005) explored animal grazing systems as an approach to gaining production from saline land. Currently there is wide interest in drainage as a means of drying out waterlogged soils and draining away the salt, but this leaves the problem of where the hypersaline and often acidic water will drain to (Ali *et al.*, 2004a,b,c). There is also expanding interest in the use of vegetative solutions, involving plantations to minimise recharge, and others to use up saline water. These plantations may be purely for environmental or aesthetic functions, but may also yield products such as timber, oils, and stock fodder. It is the renewed interest in this latter approach that led to the formation of the Sustainable Grazing on Saline Lands (SGSL) programme. However, as plants take up water they concentrate salt in their root zone (Morris and Thompson, 1983; Williamson, 1990), which may limit their ability to use water and to grow, and some modelling exercises have shown that under arid and semi-arid conditions, with little or no surplus water flushing salt from the root zone, groundwater uptake by vegetation may lead to “salting out” of the vegetation (Jolly *et al.*, 1993; Thorburn *et al.*, 1995; Slavich, 1992; Silberstein *et al.*, 1999). There is also a fundamental conflict of interest between the

use of plants to control waterlogging and salinity, by lowering or controlling watertables which requires maximum leaf area, and grazing these same plants for animal production, reducing leaf area. Slavich *et al.* (1999) found minimal water transpired (less than 0.3 mm day⁻¹) by two stands of saltbush grazed by sheep, and questioned the efficacy of treating saline land in this way if it is also expected that production will be gained. In contrast to the findings of Slavich *et al.*, Barrett-Lennard and Malcolm (1999) reported substantial accumulation of salts within the root zone of salt bush (various *Atriplex* species), indicating up to 100 mm water uptake from the groundwater over two years. This issue is at the heart of the aims of the SGSL programme, in which it is aimed to gain production while also improving saline land and environmental values.

The aim of the Salt and Water Movement Theme in SGSL was to quantify the impact of implementing a salt land grazing system on salt and water fluxes from the site, and to assess the downstream implications of large scale implementation of such a scheme. Under SGSL, experiments were established in WA, SA, Victoria and NSW, aimed at quantifying the viability of implementing a salt-tolerant pasture system, and on determining the biodiversity and off-site environmental impacts of such an activity. This paper reports some of the results, most of which will be presented elsewhere.

Site description

The analysis reported here is based on the measurements taken at the five SGSL experimental sites. Only two of these experiments (NSW and WA1) included salt and water movement, and the NSW experiment was hampered by a seasonal drought that resulted in no water flow being measured in several of their plots in most years to date. Details of the experiments at these sites can be found elsewhere (King *et al.*, 2007; Norman *et al.*, 2007), and of the experiment in Victoria (McCaskill *et al.*, 2006) and South Australia (Edwards *et al.*, 2006), and the second experiment in WA (Barrett-Lennard, *et al.*, 2006).

The site characteristics of all sites are given in Table 1.

Site	Area	Average Rainfall (mm/yr)	Watertable Depth (m)	Ground-water EC (mS/m)	Soil ECe (mS/m)
NSW Gumble	4 x 1ha	626	0.5-2	300-900	0-3,500
Avoca	2 x 5ha	585	1-3	300-1,100	0-1100
Vic Dunkeld	12 x 1ha	683	1-2	200	200-8,800
SA Mt Charles	21 x 2ha 3 x 5ha	475	0-1.5	100-2,000	100-2,700
WA Tammin	2 x 10ha 4 x 5ha	342	0.3-1.2	7,000	100-8,000
Yealering	2 x 26ha	362	0.5-1.2	2,500	200-3,000

Materials and methods

All sites were characterised following a Site Characterisation Protocol (Silberstein *et al.* (2004), and had some level of groundwater depth and salinity monitoring. All sites had a range of salt tolerant fodder species sown and grazed by sheep, and compared with control plots in which the sheep grazed remnant and volunteer pastures. The main hydrology sites (NSW and WA1) also followed the Materials Balance Protocol (Silberstein *et al.*, 2004) for the measurement of on and off-site fluxes of water and salt, using intensive groundwater and soil moisture monitoring, Bowen ratio to monitor evaporative flux, and flumes to gauge surface runoff and salt load.

Results and discussion

At Gumble and at Yealering, salt and water flux off the paddocks has been measured throughout the experiments. Unfortunately, the drought in NSW meant that there was no runoff from several of the plots in several years. From the data we do have there was a decline in surface flow measured at Gumble following treatment, but results from Avoca are inconclusive because of the seasonal

differences (King *et al.*, 2007; Hughes *et al.*, in prep). At Yealering there was also a decline in surface flow following treatment although this was less than in NSW (Silberstein *et al.*, in prep; Norman *et al.*, 2007). This is evidence that planting salt tolerant species on saline land does lead to a reduction in surface flow, and therefore a reduction in salty water contributed to streams, but not necessarily reduction in total salt.

The situation is less clear for salt export from these sites. At Gumble there was a slight increase in salt export from one of the treated sites relative to its control plot and at the other no significant change. At Yealering the data appear to show a substantial decline in salt export, but once again the seasonal conditions were such that there is uncertainty about the magnitude of this change.

The “double mass” plot shows the cumulative change in one mass flux plotted against that another to show the comparative trends. Figure 1 suggests that the surface flow comparison between the treated (North) and untreated (South) plots remained relatively unchanged for two years until late 2005. This was when the saltbushes reached a significant size and the ratio of flows between the plots fell by about 30%. The graph should be viewed with caution because of the significantly different seasons, with 2005 having by far the most rainfall. It is suggested that two or three more seasons are required to confirm this trend. Flow from the NSW sites was significantly lower, and but similar analyses also show this trend. Figure 1 appears to show a change in salt load from the treated plot relative to the untreated plot, from the middle of the wet year 2005.

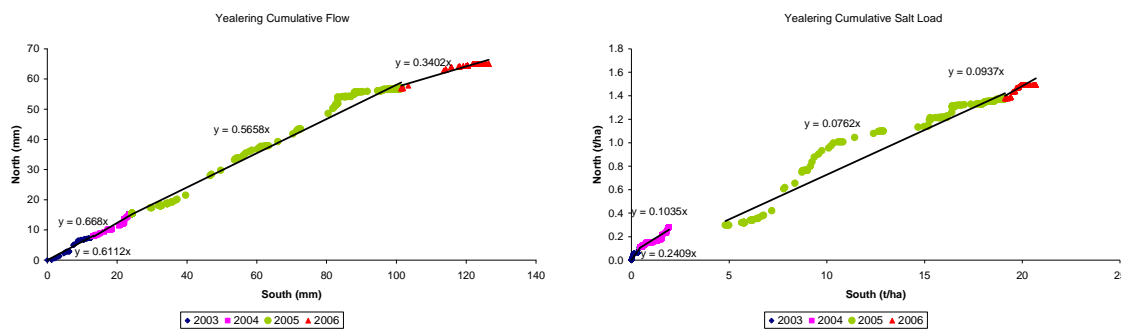


Figure 1 Comparison of cumulative water runoff and salt export from the North (treated) plot against the South (control) at Walton's Yealering, WA

A substantial mobilisation of surface soil occurred in the plots sown to new pasture and fodder species leading to top-soil erosion and deposition in the nearby stream channel and at the gauging structures. This may be a temporary effect of the surface disturbance but further data collection will be necessary to confirm this.

Conclusions

The SGSL experiments in WA ran from 2001 and in NSW from 2003, to 2007, and are the first to quantify the salt and water balances within salt land grazing systems. Results from this work suggest that implementing a salt land sheep grazing system based on perennial fodder species reduces waterlogging, possibly lowering the watertable, and reduces over-land water flow from the site by up to 30%. However, this is not universal, and varies very much from site to site.

Concentration of salts in the surface flows was observed to increase in early years, which may be due to the reduction in water flows off the sites, but total salt export increased. It is presumed that this is due to the better mixing of surface waters with the soil disturbed in the planting operation, and is probably temporary. There is a reduction in waterlogging and in average soil moisture storage above the watertable in the salt land pasture relative to neighbouring un-modified paddocks.

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