Managing saline groundwater for production and environmental benefits

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Introduction

Dryland salinity is estimated to be currently costing Australia $270 million per annum (equivalent to $14 per capita or $2,250 per farm) with expectation of $670 million in 2020 and $2 billion by 2100 (The Virtual Consulting Group and Griffin nrm Pty Ltd, 2000). The Yass River Valley in New South Wales is one of the state's most salt-affected catchments with 15% of the state's salinity-affected land in the valley and the salinity of the Yass River doubling every 10 years (Franklin, 1999).

"Talaheni" is a 250-ha mixed grazing property located between two tributaries of the Yass River, Dicks and Williams creeks, in an area that is the major dryland salinity hotspot in the valley (Franklin, 1999). When purchased in 1980, "Talaheni" suffered severe dryland salinity with numerous saline seeps causing declining pasture vigour until death left the surface vulnerable to soil erosion, resulting in extensive areas of sheet erosion and long, deep, active gullies. Productivity was low and the impact of dryland salinity was increasing.

Specific studies in the Yass Valley have provided local understanding of salinity processes (Wagner, 1987; Nicol and Scown, 1993; Acworth and Jankowski, 2001). Clearing of deep-rooting native vegetation and its replacement by shallower-rooting crops and pastures (often annual species) has precipitated an imbalance between available water (infiltration) and water used by crops and pastures. Excess water leads to deep drainage and a rise in the groundwater, mobilising salt stores in the profile. Once saline water tables are within 4 m of the soil surface, further rises increasingly affect crop and pasture production. Reversing this imbalance by reintroducing trees into the landscape has not been universally successful (see box), although long-term detailed case studies are scarce. Reasons tree revegetation may not be successful include the scale of the dominant groundwater processes operating (local, regional, or national), the scale of revegetation undertaken, landscape variation in recharge rates, and location of revegetation effort in the landscape. Despite these plausible reasons, a more telling explanation for the perceived lack of success is unrealistic expectations of the response time to revegetation effort. It has often taken decades for dryland salinity to express itself after clearing: is it then unreasonable that recovery may also take decades to materialise?

Failed: the hope that strategic tree planting would control salinity has not worked

However, their [trees] capacity to turn the tide on rising water tables, salinity and increasing soil acidity is another matter. The value of trees in solving these complex problems has been oversold. Many farmers investing scarce resources (albeit in more prosperous times) in trees, as a solution to salting, are now having second thoughts. To large extent they have been sold a pup. Much of the 'grow more trees' campaign has been based on 'best bet' scenarios, rather than real scientific evidence (Small, 1994).

Revegetation of the upper slopes and slopes just above salinity occurrences does not materially impact the salinity in the valley floors, because conditions are related to discharge of groundwater through the deep flow path. Recharge reduction by tree planting on the upper slopes reduces groundwater discharge through the shallow flow system above the clays and leads to an improvement in water logging where this is a problem. Revegetation of the hilltops to reduce the groundwater flux beneath the clays is very difficult due to poor soil conditions at these locations (Acworth *et al.*, 1997).

"We desperately hoped that small-scale tree plantings in strategic areas would fix the problem," Dr Ridley said.…"And we thought if farmers changed the way they managed their farms, then all would be well."… "We now know it's much bigger problem than that and it's society's problem" (Ridley, 2002).

Confronted with increasing dryland salinity in the early 1980s, the first farm plan developed for "Talaheni" had a major (but not total) focus on dryland salinity. This plan involved an integrated multi-pronged approach to dryland salinity that included the following actions:

- Refencing areas in recognition of soil and landscape variation to assist with grazing management; nine traditional 'square' paddocks have now given way to 38 irregular but resource-defined paddocks retaining only one of the original internal fences.
- Constructing graded and contour banks (22, for a total length of approximately 3 km) to protect lower flats by intercepting overland flow from adjoining hills; graded banks also intercept groundwater moving laterally down hill slopes before it reaches the vulnerable flats.
- Rectifying soil acidity (pH 3.6) by applying sewage ash (waste management product) and reseeding with salt-tolerant species.

- Identifying high recharge areas with low production potential and planting these areas to native tree species.
- Installing a network of piezometers for monitoring depth to, and salinity levels of, groundwater.
- Measuring dam salinity levels (30 dams) as a means of establishing spatial variation in dryland salinity risk and for assisting in identifying farm subcatchments at risk from salinity.
- Managing grazing to encourage natural regeneration of cleared hilltops where poor and shallow soils limit the pasture's capacity to use available rainfall.
- Fertilising and managing pastures to increase pasture bulk and vigour to assist in retaining rainfall where it falls for utilisation by the vigorous native and exotic perennial-based pastures.
- Fencing out native remnants and linking remnants with mixed-species corridor plantings primarily along rocky ridge lines (recharge sites) and break-of-slope (immediately upslope from potential discharge sites) areas; as such, corridor plantings provide multiple benefits by linking remnants, managing recharge, intercepting groundwater, providing for wildlife movement, and providing wind shelter to stock and pastures.

Results and discussion

Periodic summertime measurement of farm dam salinity levels (e.g., most recent range was 40 to 1,540 electrical conductivity units (µS/cm) over 29 dams on 23 December 2002) has established that, on average, salinity level decreases by approximately 15 µS/cm for each additional metre of elevation in the dam's position in the landscape (586 to 656 m ASL, r = 0.6). Salinity levels of dams reflect an integration of the spatial variation in groundwater salinity (210 to 4,360 µS/cm for same time) available to the dam (to the extent that subsurface drainage contributes to dam levels) and the surface salinity status of its immediate catchment. This suggests that a dam's elevation is a useful indicator of the relative salinity status of the dam's catchment; and therefore, the salinity level of the dams lowest in the landscape indicate a property's immediate salinity risk.

In addition, in response to the implementing of the salinity management steps of the farm plan (outlined above), weekly measurement of groundwater from the network of piezometers has shown persistent lowering of groundwater levels for more than 12 years (Figure 1).

Not only has the groundwater been lowered, the salinity level of the groundwater has declined substantially over the period (Figure 2). Consequently, the groundwater has gone from a shallow, saline liability to a deeper, less-saline asset. For one farm subcatchment in the Williams Creek catchment, the influence of tree planting on a rocky hilltop with high recharge capacity has extended more than 500 m downslope from the area planted to trees across adjoining paddocks of native and exotic pasture. For

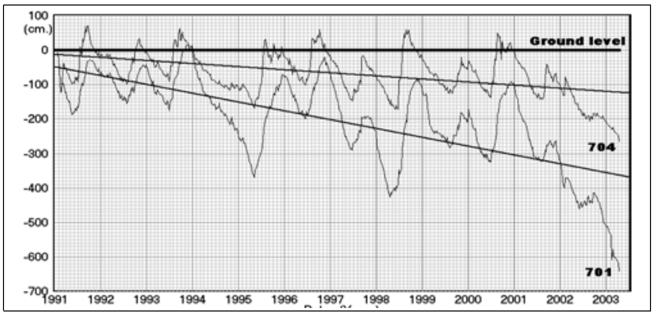

Figure 1. Weekly groundwater response from January 1991 to April 2003 to recharge area planting in 1989 with native trees. For clarity, only piezometers nearest (701, 50 m) and most distant (704, 438 m) from the tree planting are shown.

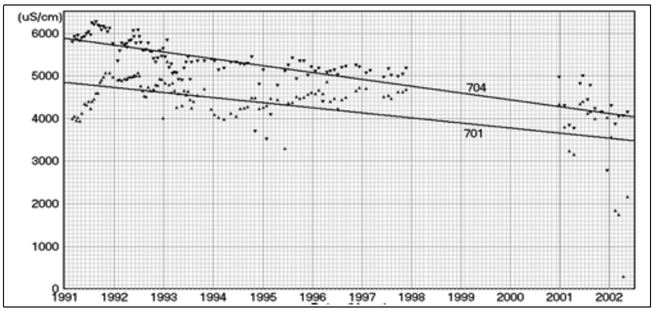

Figure 2: Groundwater salinity response associated with declining groundwater levels over the period January 2001 to April 2003. For clarity, only the piezometers nearest (701, 50 m) and most distant (704, 438 m) from the tree planting are shown.

each hectare of recharge tree planting, it is estimated that approximately 50 ha of pastureland has realised production benefits. The productivity of these pastures has increased largely in response to lower water tables with lower salinity levels, to the extent that these normally deep-rooting perennial pastures are able to now realise their potential by utilising the improved groundwater, thereby taking a part in further lowering groundwater levels. Interestingly, the perennial-based native pasture lowers the water table more than its exotic counterpart (Figure 3), presumably because of its ability to grow more actively during periods of high summer temperature.

Although managing groundwater levels and salinity delivers environmental benefit, a more revealing benefit from an agricultural perspective, at least in the shorter term, is that the improved pasture production achieved by lowering and improving groundwater quality is reflected in the commercial performance of the animals grazed (Figure 4). While groundwater level has declined by 5.3% per year, overall stock carrying capacity (1.6% per year) and the quality and performance of livestock (viz. wool index, 0.9% per year and beef index, 0.5% per year) have all increased. During this time, the area grazed has been reduced by 53.7 ha (3.3% per year) from 250 ha.

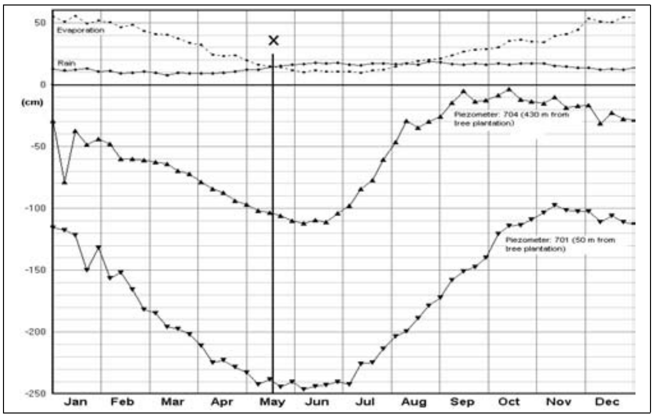

Figure 3: Mean weekly groundwater level under native perennial pasture (701) and exotic pasture (704) averaged over 12 years. Note that amplitude (difference between peak and pit) for native pasture is approx 150 cm and for exotic pasture about 110 cm. The time when water tables start to rise closely corresponds with the time when rainfall exceeds evaporation (X) and continues until just after evaporation again exceeds rainfall. Exotic pasture (piezometer 704) starts to lower the water table earlier than native pasture (piezometer 701) does, but native pasture is able to maintain a higher rate of water use during summer and autumn periods.

Conclusion

Successful management of saline groundwater has provided on-farm production benefits. In addition, public benefits have been realised, including lower salinity levels in subsurface water entering nearby tributaries to the Yass River (water supply for Yass township) and less soil and nutrient movement on and off the property to streams and neighbouring properties that have also enjoyed direct benefits.

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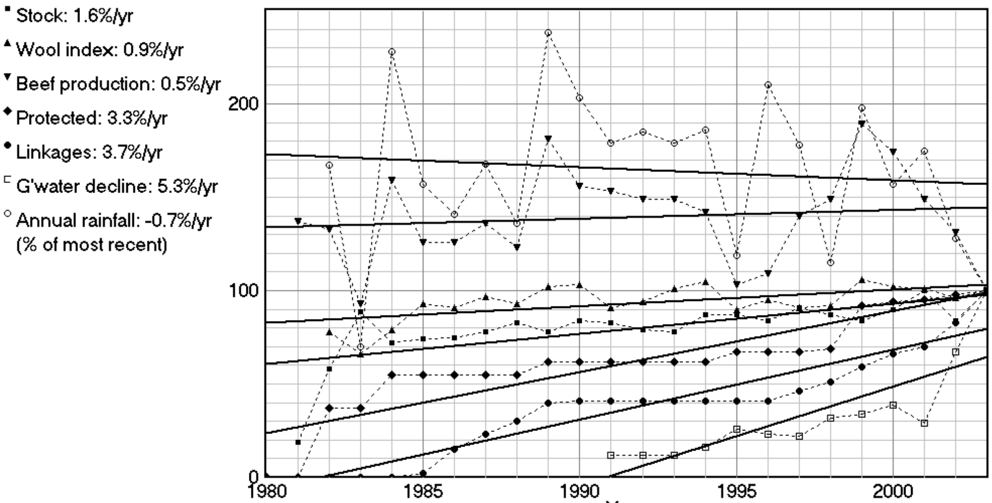

Figure 4: Gains in production and environmental indices in response to implementing a management strategy addressing dryland salinity. To enable different items to be plotted on a common scale, all have been transferred to a percentage of the most recent period (to 31 March 2003). This is then taken as 100%, and other years are scaled accordingly. Because of the serious drought conditions now prevailing, most previous years appear better (i.e., greater than 100%) for some items. The trend lines reflect the rate of change over the period; and as all have positive gradients, gains are being made across all the production and environmental items displayed.