ABARE CONFERENCE PAPER 2001.13

Assessing salinity mitigation options and their links to water property rights

Adrian Kemp, Nathan Hanna and Colin Mues
Australian Bureau of Agricultural and Resource Economics

Bundaberg Regional Outlook Conference
22 March 2001

The Queensland government, in partnership with the Commonwealth, is attempting to tackle salinity by implementing the Salinity and Water Quality Action Plan in targeted catchments across the state. Running in parallel with this initiative will be ongoing water management and allocation reform as part of the Council of Australian Governments' water reform agenda.

One of the salinity management options being considered is revegetation to reduce groundwater recharge and, hence, land salinisation and salinity levels in rivers and streams. By investigating a scenario of widespread tree planting in the Condamine catchment, it is shown that revegetation can have mixed salinity outcomes. Furthermore, there is an impact on the quantity and quality of water available to users within the catchment and further downstream. The results of the scenario are used to highlight the potential for interrelationships between salinity management and water allocation policy.

The authors would like to acknowledge the contribution of Anna Heaney to model development and design of the case study simulations, the work of Ray Evans in providing the catchment classification and hydrological components for the case study catchment, and Walter Shafron's assistance with the catchment classification analysis.

ABARE project 1706

ABARE
Innovation in Economic Research
GPO Box 1563 Canberra 2601 Australia
Telephone +61 2 6272 2000 • Facsimile +61 2 6272 2001
www.abareconomics.com

Introduction

The Queensland and Commonwealth governments recently agreed to implement the Salinity and Water Quality Action Plan in targeted catchments in that state. The indicative list of catchments for action includes the Burdekin–Fitzroy, Lockyer–Burnett–Mary, Balonne–Maranoa and Border Rivers catchments. The implementation of the Action Plan centres on integrated catchment management plans developed by the community to reverse the spread of dryland salinity and improve water quality.

Running in parallel, the Queensland government is continuing with a program of reform of the management and allocation of water resources. Through a process of consultation and planning, the government has been establishing water allocation management plans (WAMP) for each catchment within the state. The WAMPs attempt to manage water sustainably to meet ‘Queensland’s future water requirements, including the protection of natural ecosystems and the security of supply to water users.’

WAMPs have been finalised for the Cooper, Fitzroy and Burnett catchments, with draft WAMPs currently being reviewed in the Condamine / Balonne, Moonie and Warrego, Paroo, Bulbo and Nebine catchments. The remainder of the catchments within Queensland are either in the early stages or are about to commence developing a WAMP.

The aim in this paper is twofold. First, a model of land use and salinity processes is used to establish baseline projections for the future extent of salinity in the Condamine catchment in Queensland. Second, the cost effectiveness of revegetation as a salinity control option is then assessed, with particular attention on the potential impact of large scale revegetation for the availability of water for irrigation.

Revegetation to address salinity

Salinity problems arise when recharge into groundwater systems increases. As watertables rise, the discharge of saline water from groundwater systems into rivers and streams increases and land salinisation can also occur. Significant increases in recharge occurred in many parts of Australia as land was cleared of native vegetation and replaced with pasture grasses and agricultural crops.

Compared with pasture and agricultural crops, trees use a greater proportion of annual rainfall. Hence, tree planting can reduce groundwater recharge and, in doing so, reduce the extent of land salinisation and the salt loads carried in rivers and streams.

However, planting trees also has the effect of reducing surface runoff, with implications for river flows. The effect of tree planting on runoff is relatively immediate and can be potentially large. This suggests that widespread tree planting could affect the water property rights of downstream water users. In particular, it may mean a water property right held by a downstream irrigator is not well specified in that there is uncertainty about the quantity of water likely to be available to them over the long term. The characteristics of well defined property rights are summarised in box 1.

While the effect of tree planting on surface runoff is relatively immediate, the effect on the area of high watertables or salt loads in streams may not be observed for many years. Groundwater systems often respond very slowly to changes in recharge. Hence, only gradual changes in the discharge of saline groundwater into waterways are observed over many

Box 1: **Characteristics of well defined property rights**

There are five key elements that need to be in place to ensure efficient and effective water property rights that can then be traded among competing users.

In demand
Water resources must be scarce in order for potential buyers and sellers to consider coming together to form a market.

Well specified
To say that a water right is well specified implies that the licence holder has a clear understanding of their rights to access a given share of a defined water resource or to access a water resource under certain conditions.

The quantitative information available to irrigators about their water rights does not have to be perfect or risk free in order for water property rights to be well defined and for markets to be efficient. The nature and characteristics of water resources, which are affected by factors such as variable climate, mean this is generally impractical. The key issue is whether the rights are defined in a consistent way that enables market participants to assess the risk profile and, hence, market value of those rights.

Establishing an efficient, market based system of tradable water rights depends crucially on this characteristic of water property rights. Decisions about water use and investment in irrigated farming, particularly over the longer term, are strongly influenced by irrigators' expectations about the quantity of water that their statutory water rights or entitlements represent, and the expected market value of that quantity of water. The latter is influenced by the market price of water, which is itself determined by the interaction of the aggregate supply and demand for irrigation water.

Exclusivity
A well defined property right requires that all of the benefits and costs associated with the use of the good or service it represents are attributed to the owner of the right. In economic terms, this is the same as saying that there are no externalities (good or bad) associated with the use of the right. This will be the case where all of the benefits and costs associated with using the right are private, and hence are reflected in the market price of the right. Problems arise, however, when the use of a resource is associated with noncommercial benefits or imposes costs on third parties for which the resource owner is not liable.

The existence of an externality does not, however, automatically justify intervention or changes to the conditions governing the use of water rights in order to improve the 'exclusiveness' of water rights. Having identified a problem or issue relating to the use of water rights, the key issue is whether or not the total benefits of intervening to address the problem are greater than costs.

Box 1: **Characteristics of well defined property rights** *continued*

Enforceable and enforced
Regulations and enforcement systems should exist to ensure that water property rights are upheld. If rights are not clearly defined or if a government does not publicly recognise and enforce a property rights regime, the value of these rights will be reduced and the operation of the market in water rights will be hampered. As noted above, in practical terms, water users are likely to be particularly cautious about how much they would pay for a right of uncertain status and value. As a result, the value of water rights would be lower than in the absence of this risk. Desirably, there should be some responsibility for water management agencies to adequately specify risks in terms of probabilities of being able to supply the resource according to a set of parameters on future scenarios.

Transferable and divisible
Transferability refers to the ability to transfer ownership of property rights. Transferability of water rights is essential to the establishment of a market and encouragement of efficient resource use.

As with most markets for goods and service, however, some restrictions on the trading of water rights may be justified in certain circumstances. For example, restrictions on the transfer of water rights may be justified if the transfer:

- is not hydrologically possible;
- significantly increases transmission losses – thereby attenuating the rights of other licence holders; or
- causes or exacerbates external costs (such as reducing the quality of water owned by other irrigators or the environment)

Inevitably changing water management practices and land use has an impact on water property rights, often by changing the availability of water to downstream users. Therefore, not only is it important to ensure water property rights are well defined, but it is also important to understand the interrelationships between land use change, property rights and environmental outcomes.

years following a reduction in recharge. Consequently, revegetation aimed at reducing stream salinities can actually lead to an increase in stream salinities in the short term because there is less water to dilute the slower changing salt loads.

In analysing the net salinity benefits of revegetation, Heaney, Beare and Bell (2000) considered the net value of any change in the area of agricultural land affected by high watertables, the effect of short and long term changes in stream salinities on downstream water users and any reduction in water availability for irrigators, each calculated relative to baseline projections. Their analysis showed that widespread revegetation in the Macquarie–Bogan catchment in New South Wales was not a cost effective option for salinity control. Given the average levels of groundwater salinity, soil characteristics and aquifer response times, widespread revegetation in the upper catchment led to a proportionally greater reduction in surface runoff than in stream salt loads. Hence, under this scenario, stream salinity was actually projected to be higher in 100 years time compared with the baseline projections and economic returns from agricultural and forestry land uses in the catchment were reduced by around $50 million in net present value terms.

Heaney et al. (2000) went on to show that in the Macquarie–Bogan catchment targeted revegetation was a better salinity control option. However, other catchments have different hydrological and agroeconomic characteristics as well as different productive (and nonproductive) assets at risk from salinity. This suggests the cost effectiveness of revegetation as a salinity control option is also likely to be different.

The remainder of this paper is spent examining the effect of widespread revegetation on salinity outcomes in the Condamine catchment in Queensland. Implications for the availability of water for irrigators both within and downstream of the catchment are also considered.

A case study of the Condamine catchment

The case study analysis of revegetation in the Condamine catchment uses a model of land use and salinity processes developed by ABARE in collaboration with CSIRO as part of a partnership project with the Murray Darling Basin Commission (see Bell and Heaney 2000). The model allows for the relationships between land use or vegetation cover and surface and groundwater hydrology. Hence, it explicitly accounts for both surface runoff and groundwater recharge effects of land use change, and for the sluggish response of groundwater systems to changes in recharge. The model also estimates the value of the economic benefits derived from different irrigated and dryland agricultural land uses in each of the catchments covered by the 1999 salinity audit conducted by the MDBC. By design, it is a useful tool for comparing the cost effectiveness of alternative salinity mitigation options in different catchments of the Murray Darling Basin.

The modeling approach is to separate catchments into smaller subcatchments with similar groundwater flow characteristics. The baseline projections presented below are for the middle of the Condamine catchment located roughly between Condamine and St George (table 1).

Although salt loads are currently low, they are projected to almost double by 2050. This increase is caused by the gradual increase in groundwater discharge to streams arising from the increase in recharge that occurred many years ago as native vegetation was cleared

Table 1: **Baseline projections of salinity for the mid-Condamine subcatchment**

	Unit	**2000**	**2050**	**2100**
Salt load leaving the mid-Condamine subcatchment	kt	87	164	619
Average salinity of river flows for irrigators downstream from the mid-Condamine subcatchment **a**	mg/L	115	254	676
Area of high watertables	ha	0	21 559	155 521

a The salinity of river flows for irrigators downstream from the mid-Condamine subcatchment is also affected by the increasing salt load from the Maranoa subcatchment.

for agriculture. The groundwater aquifers in that part of the catchment are, on average, very slow, taking hundreds of years to come into a new equilibrium once the level of recharge is changed. Hence, the full salinity consequences of past land clearing remain to be seen.

The projected change in average stream salinities for downstream irrigators over the next fifty years mirrors the increase in salt loads. Clearly, deteriorating water quality will have an increasingly large impact on irrigated agriculture around St George in coming decades. The area of agricultural land affected by high watertables is also projected to expand significantly from none today to more than 20 000 hectares in fifty years time.

The revegetation scenario considered was the planting of 30 000 hectares of trees to replace grazing land in the mid-Condamine subcatchment. This area has very salty groundwater. The average salt concentration in the groundwater is around 20 000 mg/L which is higher than almost every other dryland catchment in the Murray Darling Basin. The trees were planted over a five year period with a rotation length of around thirty years. The results from this scenario, reported with the baseline projections are reported in table 2.

Planting trees on 30 000 hectares is not sufficient to reverse the trend in salt loads coming out of the mid-Condamine subcatchment, although the rate of rise is marginally slower. By 2100, salt loads are projected to be just 2000 tonnes less than in the baseline, but more than fivefold greater than current levels. It takes many years to observe a drop in salt loads relative to the baseline because the groundwater systems in this part of the catchment are, on average, very sluggish.

Notwithstanding the aquifer characteristics, there are a number of other factors that mitigate the effectiveness of revegetation in reducing recharge and, hence, salt loads. First, the difference in the amount of evapotranspiration from pastures and crops compared with

Table 2: **Results from the revegetation scenario for the mid-Condamine subcatchment**

	Unit	2000	2050	2100
Salt load leaving the mid-Condamine subcatchment				
Baseline	kt	87.4	164.3	619
Tree planting scenario	kt	87.4	163.5	617
Average salinity of river flows for irrigators downstream from the mid-Condamine subcatchment a				
Baseline	mg/L	115	254	676
Tree planting scenario	mg/L	115	257	682
Area of high watertables in the mid-Condamine subcatchment				
Baseline	ha	0	21 559	155 521
Tree planting scenario	ha	0	21 540	155 382

a The salinity of river flows for irrigators downstream from the mid-Condamine subcatchment is also affected by the increasing salt load from the Maranoa subcatchment.

trees is less in this subcatchment than in other regions with higher average rainfall. Second, more of the excess water (rainfall in excess of plant requirements) ends up as surface runoff than it does as groundwater recharge with heavy clay soils that are typical of this area. This means the surface runoff impacts of revegetation are likely to be greater than the reduction in recharge.

Although it takes many years for salt loads to change, the impact on surface runoff is relatively immediate. Compared with the baseline, stream flows out the mid-Condamine subcatchment in 2050 are reduced by around 14 GL. This would be expected to have implications for environmental flows or irrigators within or downstream of the catchment, depending on the water allocation policies in place at the time.

Compared with the baseline, stream flows are reduced and salt loads largely unchanged in the short term. Hence, large scale revegetation actually leads to an accelerated rise in instream salinity from the loss of the dilution effect from surface runoff. This means irrigators around the St George area are likely to suffer yield declines caused by falling water quality earlier than they would have otherwise. Even in 2100, water quality is projected to be worse than in the baseline because the reduction in surface runoff is proportionally greater than the reduction in salt load.

Although the mid-Condamine subcatchment is part of the larger MDB system, these water quality effects are largely restricted to the Condamine–Culgoa catchment. The contribution from that catchment to instream salinity problems lower in the Murray Darling Basin is small.

Reflecting the very sluggish groundwater systems in the mid-Condamine subcatchment, tree planting is also unlikely to have any noticeable effect on the area of agricultural land affected by high watertables over the next fifty to one hundred years.

Over the next hundred years, the planting of 30 000 hectares of trees is estimated to reduce the value of economic returns from the different land uses in the Condamine–Culgoa catchment by $11.3 million in net present value terms. This is comprised of two main elements. First, the expected return to forestry activities in that region is not likely to match the returns from existing agricultural land uses. Second, the revegetation leads to an earlier rise in the salt concentration of water used for irrigation further downstream than is projected to occur under the baseline.

Conclusions

As part of the Salinity and Water Quality Action Plan, the community of the Balonne–Maranoa will soon be preparing a catchment management plan to address the issue of salinity and water quality. Although the current extent of instream and dryland salinity in the mid-Condamine catchment is low, the projections from ABARE's model of land use and salinity processes suggest this is likely to deteriorate significantly over coming decades. Developing cost effective solutions to these problems is clearly a priority for the community and government agencies involved.

The case study results highlight that effective salinity management is not simply a matter of planting trees in the areas with the most saline groundwater. The responsiveness of aquifers to changes in recharge and the surface runoff effects should also be taken into account. In the case study presented, a strategy of large scale revegetation reduced economic returns by around $11 million in net present value terms but delivered very little in terms of effective salinity outcomes.

The results of the case study also highlight how aquifer response is likely to be a key factor influencing choices in the design of strategies to meet shorter term salinity targets. Where groundwater systems respond very slowly to a change in recharge, the short term salinity outcomes from revegetation are likely to be dominated by the effect on surface runoff. This suggests alternative interventions, such as engineering works to prevent saline groundwater discharge into streams, may be a more cost effective approach to meeting these targets.

The implication of these issues is that community based catchment groups will need to be provided with adequate technical support to enable them to work through the complex range of biophysical and economic issues involved. In this regard, the investment in salinity response teams proposed as part of the Salinity and Water Quality Action Plan and the technical support from state agencies will be critical to the development of effective catchment management plans.

With many Queensland catchments going through the WAMP process, the case study is also a timely reminder of the potential for land use change to affect the property rights of irrigators. The extent to which the availability of water for irrigation is affected by land use change will differ from catchment to catchment due to differences in climate and soil types. This, in conjunction with issues such as the economic benefits derived from irrigation, will be factors to consider in deciding whether to explicitly deal with these issues when defining water property rights.

References

Bell, R. and Heaney, A. 2000, *A Basin Scale Model for Accessing Salinity Management Options: Model Documentation*, ABARE Working Paper 2000.1, Canberra, August.

Heaney, A., Beare, S. and Bell, R. 2000, 'Targeting reforestation for salinity management', *Australian Commodities*, vol. 7, no. 3, pp. 511–18.