Theme 6 Project 3.4

Structural Change in Australian Agriculture: Implications for Natural Resource Management

Part 2: Salinity Case Studies

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Summary

This report discusses four regional case studies and examines the capacity of the local and the wider community to change in a manner that might achieve improved salinity control. The study utilises the outcomes of biophysical, economic and social modeling undertaken within other projects of Theme 6 of the National Land and Water Resources Audit to explore this theme.

In the Vanilla catchment of the Eyre Peninsula in South Australia, it is concluded that the only practical option available to the local community is to learn to live with salinity. Whilst this might contain some pain, it is less painful than the alternative of recharge control.

In the Kamarooka region of Victoria there is little likelihood of an expansion of the existing extent of salinity. The existing salinity damage is recoverable over a century with the replacement of annual pastures with lucerne pastures. The local farm community has already undertaken extensive planting of dryland lucerne. However, further planting will be mediated by the relative returns of cropping and grazing enterprises. At present, and for the foreseeable future, it is likely that cropping will remain more attractive. In the longer term, there is reason to question the extent to which farming will remain a dominant land use in this district.

In the Lake Warden catchment of Western Australia there is a rapidly expanding shallow watertable. The local farm community has the capacity to increase the area of dryland lucerne to reduce the recharge of watertables. Anecdotal evidence is that this is well underway. However, whilst this will reduce recharge, in the long run it will delay but not reduce the ultimate impacts of dryland salinity on farm land. Delaying the ultimate expression of salinity will reduce the social and economic impact of salinity by providing a far longer time for structural adjustment. Even in the short to medium term it is unlikely changes to existing farming systems will save the downstream wetlands of Lake Warden. A landscape change option to save these wetlands based upon extensive reforestation would impose social and economic costs on the local community far greater than the costs of unmitigated salinity.

Upper Billabong Creek is perhaps the most instructive case study. An investment in improved understanding of catchment processes has revealed a far lesser salinity problem than initially expected on the basis of limited monitoring and best bets understandings of salinity process. This underlines the importance of reliable science based understandings of regional salinity as a foundation for public investment decisions.

The key lessons derived from the case studies are:

- There is no simple broadly applicable paradigm with which to conceive our responses to salinity.
- Expectations of farm based change leading to salinity control need to be tempered.
- Broad scale reforestation proposals will often be poor investments from an economic and social perspective.
- A lack of profitable technically feasible options is the major constraint to the capacity to control salinity.
- The major issue of “capacity for change” is the capacity of our community to make informed decisions about investment in salinity control.
• We need to re-engineer our integrated catchment management structures to operate within an adaptive management framework.

• Investment in salinity control should be based upon a triage model.

• A “works on the ground now” imperative should be tempered by a “least regrets” investment approach.

• Landscape change must be seen as a multi-generational challenge.
What is capacity to change?

This project was commissioned by the National Land and Water Resources Audit as a study of the “Capacity to Change” within four case study regions. The assumptions behind the project formation were reasonably simple and familiar to those who have worked with natural resource management policy over the past decade. These assumptions can be summarised as follows:

- There is a natural resource management problem in these catchments, in this case rising watertables and eventual increases in the area of dryland salinity.

- This natural resource management problem can be controlled or ameliorated by changes in land use management by existing landholders.

- It is in the public interest that these changes in land use are facilitated.

The key questions for the project was the extent to which the implementation of land use changes to reduce recharge were within the capacity of existing landholders in each of the four case study catchments.

The progress of catchment modelling and economic analysis funded by the National Land and Water Resources Audit has brought these assumptions into question for a number of the case study areas. The hydrogeologic modelling of some case studies has indicated that for some areas there may be no available agronomic solutions to rising water tables. The economic analysis has demonstrated that in some of these catchments a decision to control watertables by land use change will entail a significant net cost to the Australian community that far outweighs any economic benefit from salinity control. These findings change the nature of questions about “capacity to change”. Whose capacity to change are we to consider? Are we talking about existing landholders, future landholders or the capacity of the wider social and economic systems. What change are we considering? Is it change to control salinity, or changes to learn to live with the future extent of salinity?

In the following chapters the question of “capacity to change” is discussed in the context of the four regional case studies: Vanilla in South Australia, Kamarooka in Victoria, Lake Warden in Western Australia and Upper Billabong Creek in New South Wales.
Wanilla: Living with salt

The catchment

The Wanilla catchment is a small basin of about 17,000 hectares, situated about 40 km to the north west of Port Lincoln on the lower Eyre Peninsular, South Australia.

Figure 1 Location of Wanilla catchment

Eighty six per cent of the catchment is cleared and used for cropping and grazing. The total number of farms is about 25. Most of the uncleared area comprises remnant vegetation. Of the approximately 2,400 hectare of remnant vegetation, about 600 hectare is located in a Conservation Park at the lower end of the catchment, while the remainder lies mainly along (mainly saline) drainage lines throughout the catchment.

The farm community

Data on the distribution of farm types and sizes is available from the Australian Agricultural Census (ACC). This data is normally aggregated to the Statistical Local Area. In the past data has been available aggregated to “Hundred” boundaries. The hundred is a unit based upon the South Australian cadastral base. However, data will not be available at this level for the 2001 Agricultural Census and beyond. The Wanilla catchment lies fully within the Lower Eyre Peninsula Statistical Local Area. However the catchment occupies only a minority of the farming area of this SLA. In the 1996/97 the ACC enumerated 247 establishments in the SLA. Broadacre cropping was reported on 232 of these establishments. Sheep were reported on 223 establishments and beef on 84 establishments. No other agricultural activity of significance was reported. The SLA appears to be a homogenous mixed broadacre farming area. Data for the SLA is likely to be representative of the Wanilla catchment community.

In 1996/97 the median farm gross value of farm production was approximately $160,000. This was estimated from ABS Estimated Value of Agricultural Operations data. There were very few small hobby farms in the SLA. Twenty-five per cent of farm establishments had a gross
value of production less than $100,000. Only 18 per cent of farm establishments had an Estimated Value of Agricultural Operations greater than $300,000. These larger farms managed 40 per cent of the farm area in the SLA. It is clear that farms in the catchment are not large and are unlikely to be generating surpluses capable of funding significant land use change.

![Location of Wanilla catchment and the Lower Eyre Peninsula SLA](image)

*Figure 2 Location of Wanilla catchment and the Lower Eyre Peninsula SLA*

The Population and Housing Census provides a better opportunity to examine the family incomes of the Wanilla catchment community. The Wanilla catchment lies predominantly within the boundaries of Collector District 4021607. Likewise, the majority of the agricultural land of the Collector District lies within the Wanilla catchment. We can use census data from this collector district with reasonable confidence it represents the social conditions within the Wanilla catchment. In 1996 the median farm family income was $41,000. This was an above average income reflecting the favourable commodity prices of the previous year. When averaged over the past three censuses, the average income is $28,000 (in 1996 dollars). On average, 23 per cent of farm families had average incomes over $50,000. Fourteen per cent averaged less than $20,000. When compared with gross farm incomes, these family incomes suggest that there is some dependence upon off-farm income. During the period 1986 to 1996, the ratio of farm families to farm establishments fell from 96 per cent to 80 per cent, suggesting that dependence on off-farm income has increased. In this time the number of persons described their main occupation as farming fell from 32 to 16. Farmers in this catchment are younger than the national average.
**Salinity control**

*BRS and CSIRO* have developed a water balance model for the Vanilla catchment (Stauffacher et al. 2001). That model predicted there will be an expansion in the areas of high watertable from the current 8 per cent to 15 per cent of the catchment over the next 20 years with a continuation of current land use and agricultural practice. Within 50 years the extent of the catchment with high watertables was predicted to grow to 16.8 per cent.

The model was then used to estimate the areal extent of high watertables over 20 years and 50 years, but with current levels of recharge reduced by 50 per cent. A 50 per cent reduction in recharge would lead to an increase from 8.1 per cent to 11.7 per cent of the catchment with high watertables over the next 20 years and 12.9 per cent over the next 50 years. A 50 per cent decline in recharge would prevent 3.7 per cent of the catchment from coming under the influence of high watertables within 20 years. It would prevent 3.9 per cent of the catchment from coming under the influence of high watertables.

The BRS and CSIRO team used a farm scale water balance model to explore how a 50 per cent reduction in recharge could be achieved by changes in land use. Unfortunately, a 50 per cent reduction in recharge could not be achieved using existing agricultural options. The modelling team concluded as follows:

> The modelling of farm scale water balances indicates that increases in cropping area will continue to increase overall catchment recharge; even with best management practices. Lucerne is the only agronomic option currently available (if it can be established and grown successfully – a problem given the number of soil constraints) that may achieve recharge rates appropriate for salinity control. The 50 per cent recharge reduction postulated in the groundwater modelling (which still sees an expansion of the discharge zone) is not achievable under any options other than native vegetation”.

The economic analysis of this scenario concluded:

> Landholders would be even worse off if they adopted the catchment-wide treatment proposed to achieve a 50 per cent reduction in recharge. They would be much worse off, primarily because
farm forestry would be extremely unprofitable. Further, it seems that the switch to lucerne in crop rotations would either only break even with the returns from conventional pastures or result in lower returns than conventional pastures. Compared to implementing no management, landholders would be worse off by somewhere in the range $15 million to $40 million over the next 50 years. From an economic or financial viewpoint, they would be better to live with the salinity rather than to participate in the proposed catchment-wide treatment. They would prefer to see the salinity in the Vanilla catchment continue unabated, and their total net farm incomes over the next 50 years would be reduced by about 18 per cent due to the dryland salinity. This outcome reflects primarily the poor yields from woodlots or lucerne which would lead to a very much greater reduction in income than would the unabated salinity. The only offsetting benefit that we have estimated is a reduction in the future rate of increase in road impacts which, using a 5 per cent discount rate, would represent a total of $0.03 million over the next 50 years (Read Sturgess and Associates 2001).

It is hard not to agree with the final conclusion of the economic analysis… that:

landholders in the Vanilla catchment are clearly not going to adopt the proposed catchment-wide planting of trees and lucerne, as it will send them broke. Technical advances leading to lucerne or trees better suited to the Vanilla catchment probably represent the only possible way to make a switch to trees and lucerne profitable for the difficult soil conditions of the Vanilla catchment.

How can we reinterpret the question of capacity to change in the light of these findings? Catchment scale changes to vegetation cover to control salinity are clearly not within the capacity of existing landholders.

**The live with salt option**

The economic analysis of the impacts of salinity in the Vanilla catchment concluded that 95% of the impact of salinity was upon agricultural income. Over the past 40 years the Vanilla community has lived with the impact of salinity. In this time 8 per cent of the catchment has come under the influence of high watertables, and by 2000 approximately twelve per cent of the potential production value was being lost on an annual basis. Figure 4 makes a notional comparison between the general terms of trade trend for Australian farms and the impact of current salinity loss upon the Vanilla catchment, assuming that the current loss has occurred at a linear rate over the past 40 years. This simple comparison makes it clear that, for the catchment in aggregate, the impact of terms of trade decline is far greater than the impact of salinity loss. When the additional incomes effects of seasonal variation are added, it is easy to conclude that the financial impact of salinity losses would be difficult to discern amongst the impact of other influences on farm financial performance. This simple fact explains why farmers generally see salinity as a background issue in comparison to commodity prices, seasonal conditions and farm costs.

One response to the continued compression of farming terms of trade is to seek productivity increases in farm businesses. Many productivity increases in broadacre agriculture are based upon increased production per labour input. As a result, farm sizes increase and the number of farmers decreases. During the decade between 1986 and 1996, farm establishment numbers in the Southern Eyre SLA declined by 1.2 per cent per annum. The number of farm families declined by 1.8 per cent and the number of farmers by almost 2.8 per cent per annum. Within collector district 4021607, which more closely corresponds with the Vanilla catchment, the number of farmers declined by 50 per cent over the same decade, a compound annual rate of over seven per cent. These statistics paint us a picture of farm community which has adjusted radically to the pressure of terms of trade decline, adverse seasonal conditions and salinity by both farm aggregation and the seeking of other sources of income while remaining on the farm.
Figure 4 Notional comparison of the impact of terms of trade decline and salinity loss upon the Vanilla farm community

The modelling of the catchment hydrology suggests that the equilibrium level of salt in the catchment will be double the current level of salinity (16.8 per cent). Much of the progression to this equilibrium will occur over the next 20 years. The rate of these salinity losses will become double that currently being experienced. Under this scenario, Vanilla farmers would bear a 22 per cent decline in net agricultural income during the period 2001 to 2021. During the same period, we would expect the long-term terms of trade decline to reduce farm net incomes by 32 per cent. The individual and aggregate impact of these pressures is shown in Figure 5.
Figure 5 Notional comparison of the impact of terms of trade decline and salinity upon farm net incomes (assuming no productivity improvements)

Whilst the added impact of salinity is still not as great as the impact of the terms of trade decline, it is clearly now more significant than that which is portrayed in the previous figure. This is a result of the predicted faster rate of watertable growth in the next 20 years. The potential social and economic impacts of production losses from resource degradation are a function not just of the absolute losses, but also the rate at which losses occur.

Modelling undertaken as part of the National Land and Water Resources Audit has given us a number of scenarios of farmer population over the period 2001 to 2021 (Barr 2001). These are presented in Figure 6. The scenarios are based upon a stock and flow model using 5 year intervals. There is potential for a 35 to 65 per cent decline in the number of farmers in the South Eyre SLA. A mid range estimate is a decline of approximately 50 per cent. If we assume that a decreased net income of 22 per cent will have an equal linear impact on the rate of farmer exit, the net result would be to shift the mid range estimate of declining farmer numbers down to a net decline of 65 per cent.

Figure 6 Scenarios of change in farmer numbers for the South Eyre SLA: 2001-2021

Over the next 20 years the social and economic impact of dryland salinity on the Wanilla catchment is going to increase significantly. However, this increased pressure is still less than the continuing impact of the terms of trade upon the agricultural community. The Wanilla agricultural community has undergone significant adjustment over the past 20 years, mainly in response to the terms of trade decline. That rate of adjustment is going to increase as a result of salinity. Of course, this analysis has assumed an even distribution of salinity costs across Wanilla farms. In reality, it is likely that the costs of salinity will not be evenly experienced.
The salinity control option

Hydrological modelling suggests that a 50 per cent reduction in recharge across the catchment would achieve a reduction in the future growth of salinity. It was proposed that the 50 per cent reduction in recharge could be achievable by replacing all upper catchment farmland with trees and replacing all pastures in the lower catchment with lucerne. The tree plantations in the upper catchment would be used to supply firewood to the Adelaide market. The economic impact of these changes to the catchment landscape depended upon the assumptions on the production levels that could be achieved with these crops. Optimistic assumptions produced a reduction in net farm incomes of 35 per cent. Pessimistic assumptions saw the total elimination of net farm income. Read concluded:

Clearly landholders in the Vanilla catchment are not going to adopt the proposed catchment wide planting of trees and lucerne as it will send them broke.

The scenario based upon adoption of this outcome is utterly unrealistic. There is no precedent in the history of Australian rural industries for landholders to adopt such unsuitable technologies across a landscape, let alone in a time frame sufficient to reduce the impact of salinity on the Vanilla. Both the hydrogeological modelling and the economic analysis assume that the 50 per cent recharge reduction scenario is immediately adopted. Even if the proposed alternative land uses were not clearly unprofitable, such an assumption of immediate 100 per cent adoption is not tenable. In areas where lucerne is profitable, adoption has been gradual, as a response to the increased management skills required to fully exploit it as part of a mixed cropping system. Typically, there may be a 10 or 20 year lag between the commencement of adoption of a pasture-based system and its final adoption level (Barr & Cary 1992). The adoption of forestry systems requires significant initial capital investment. ABS data tells us that capital availability will be a significant issue. In the period 1986-96 the average farm family income was $28,000 (in 1996 dollars). Only 25 per cent of farm families achieved an average family income greater than $50,000. The capacity to generate a capital surplus in any one year will be quite limited.

Adoption over a period of a decade or more is a natural outcome of the desire of most managers to manage risk through trialling or watching the outcomes of the adoption of others. Whilst a decade would allow producers to explore the risks of alternate pasture based systems of production, the risks of plantation development would not be fully amenable to exploration. There is a question of social justice in encouraging the adoption of low profitability and potentially high risk such as firewood production. The only market for wood products appears to be firewood in Port Lincoln and Adelaide. The economic evaluation of salinity control in the Vanilla catchment considered a static market situation. Widespread adoption of firewood based forestry in other catchment areas seeking recharge control could risk over supplying the fire wood market. The predicted prices used in the economic evaluation may be superceded. Further uncertainties may be introduced by future concern at the air quality impacts of wood fires in urban areas leading to a regulated impact of demand for the product. The recent rapid turnaround in the market outlook for plantation based wood chips is an indicator of the potential of widespread adoption to have a detrimental impact upon prices.

A more realistic, but still very optimistic assumption is that further research develops new pasture and forestry farming options and that after the development these are adopted over a 10-year period. Such a change is likely to to take at least 15 years before full adoption. During this period most of the preventative benefits of recharge reduction will be lost As a consequence, much of the salinity damage predicted for the next 20 years would have occurred before the full impact of land use changes would be felt. Most of the salinity induced additional adjustment pressures on Vanilla farmers predicted in the “no intervention” scenario would be unavoidable, despite the eventual adoption of salinity control options.
Conclusions

There is little prospect of significant adoption of any of the salinity control scenarios proposed in the modelling. They offer no economic incentive to landowners, they are technically unsuited to the area and there is limited time for the development and adoption of new options before the full extent of salinity impacts is experienced. Implementation of current options would rapidly accelerate the existing rates of decline in farm population and make the “live with salt” option seem attractive by comparison, even though this option is unpalatable in isolation. Given that hydrological equilibrium is predicted to be reached within 20 years, it appears there is little prospect of further research producing alternative salinity control options that could be adopted before the full extent of salinity is reached. From the viewpoint of the nation, there would seem to be few compelling reasons to invest in landscape change in Wanilla. There are no significant off-site impacts from salinity as it drains directly to the sea. Given the call on salinity control funds from other regions with strong cases, investment in Wanilla catchment cannot be argued to be a priority. Perhaps the major issue for national attention is support for communities that are faced with no option but to live with salinity. Such support should be seen as part of a wider policy of supporting the viability of rural communities, rather than solely as natural resource policy initiative.
Kamarooka: Capacity mediated by external factors

The catchment

The Kamarooka case study is a small area located half an hours drive north of Bendigo on the northern edge of the Whipstick forest. Kamarooka is on the boundary between the northern slopes of the Great Dividing Range and the riverine plains of the Murray Darling Basin. Farming is based upon both the traditional sheep-wheat mixed farming system and grazing enterprises. The balance of cropping enterprises is greater in the lower part of the catchment.

The farm community

The Kamarooka district case study illustrates the difficulties of using ABS data to explore social conditions in small areas without access to geo-coded data. The Kamarooka district fulfils the adage that great battles occur at the intersection of four maps. It lies straddles on the border of the Loddon North and Greater Bendigo Part B SLAs. It borders the Campaspe SLA. The Kamarooka district does not comprise a significant area of any of these SLAs. In fact, ACC data from the Loddon North SLA will be quite unrepresentative of the Kamarooka area, being dominated by irrigated agricultural production from irrigation farms to the north of Kamarooka. The Greater Bendigo Part B SLA is the best source of data about the structure of agriculture in the Kamarooka region, although this is only indicative data. While the Kamarooka region is a homogenous mixed farming area, the Greater Bendigo Part B SLA contains a broader mix of enterprises. Of the 256 establishments within the SLA in 1997, 201
ran sheep, 147 cropped, 101 ran beef, there were 12 dairy farms, 14 horticultural properties and some large poultry businesses. This difference needs to be remembered when considering the Estimated Value of Agricultural Operations data available from the AAC. Similar problems are apparent when using collector district data to describe family incomes in the Kamarooka area. The case study area

In 1997 the median farm gross income in Greater Bendigo Part B SLA was less than $50,000. This is very small compared to the other case studies. Less than 10 per cent of farm businesses had a gross income (EVAO) greater than $300,000. Despite these low levels of gross farm income, farm family incomes were little different from that of the Wanilla or Lake Warden catchment. In 1996 the median farm family income in the Greater Bendigo Part B SLA was $33,000. Clearly the majority of farm family income is earned from off-farm sources. The close proximity to Bendigo, a major regional service centre with a population of greater than 60,000, provides a range of employment opportunities.

Figure 8 Kamarooka study area and the Greater Bendigo Part B SLA
Salinity control

The salinity in this small area is typical of much that occurs along the inland slopes of the Great Dividing Range of south east Australia. Recharge occurs on the hills and slopes. Discharge occurs along the break of slope. The case study area has 400 hectares of salinised land and affects 10 per cent of the study area. Salinity in the Kamarooka district is limited to those properties with land along the break of slope.
Modelling of the groundwater systems suggest there will be little growth in the current extent of salinity with “no intervention” (Hekmeijer et al. 2001). The salinity situation is at equilibrium. A 50% recharge reduction would lead to a 50 per cent reduction in the area at risk to salinity within 20 years and an eventual elimination of salinity in 100 years. This reduction in recharge could be achieved through a conversion of existing annual pastures to lucerne. Economic analysis by Read-Sturgess suggests this conversion is profitable for landholders, offering the potential to increase gross margins by 40 per cent. This finding is in line with extensive work undertaken by local advisory staff who have modelled the financial returns which accrue from the conversion of a traditional annual pasture grazing system to a full lucerne production system (Ransom 1992).

A 90 per cent reduction in recharge by trees reduces the area of high watertables much more quickly. There would be a fifty per cent reduction in the area of saline land within 20 years and a complete reduction within 100 years. A 90 per cent recharge reduction is achievable by the introduction of 80 per cent tree cover on those parts of the study area upstream of the break of slope. Read-Sturgess estimate this would lead to a 40 per cent reduction in net farm incomes over a fifty-year period.

The adoption of dryland lucerne

Whilst the 90 per cent recharge reduction appears extremely unattractive to landholders, the lucerne option appears to promise a very positive outcome. It offers the potential to significantly increase farm revenue in comparison to traditional grazing systems whilst gaining significant recharge benefits within this case study area. Dryland lucerne has been promoted as a farming system for over a decade and the adoption of this system has been relatively well monitored. The results of this research provide us with both positive and negative messages. There has been a significant increase in the adoption of dryland lucerne during this period. However, the rate of adoption is mediated by a number of factors which lead to the conclusion that full adoption is extremely unlikely to be ever attained.

In 1991 the Department of Agriculture conducted a survey of dryland lucerne adoption in north central Victoria. The Kamarooka area was included within this study. Using very conservative assumptions about the non-respondents, the investigators concluded that the area of lucerne had increased from 4.2 percent of farmland in 1984 to 7.6 percent in 1991. A segmentation analysis revealed adoption was limited to a small number of producers, but that there was a very high latent interest in growing dryland lucerne. Ninety farmer respondents were segmented into the following groups:

- **Established lucerne growers.** This group consisted of six farmers who had a history of good lucerne establishment, management and a very positive attitude to lucerne. The established lucerne growers had on average 43 percent of their farm under lucerne. Fifty per cent of the lucerne in the catchment will be found on this relatively small percentage of farms. Farm sizes were higher than average.

- **Lucerne planners.** This group of 29 farmers believed lucerne had a major role in their future farming plans and believed the practical problems associated with lucerne could be overcome.

- **Deterred growers.** This group of 31 farmers had little lucerne on their farms. They would like to have a larger area, but believed there were too many practical problems to make this a worthwhile goal.

- **Disinterested.** This group consisted of 24 farmers who mostly believed there was little place for lucerne on their farms. This group were also less likely to be members of landcare type groups. Farm sizes were smaller than average.
This segmentation revealed the importance of finding easily adoptable solutions to the technical and management challenges posed by the integration of dryland lucerne into the traditional cropping/annual pasture mixed farming system used in the district. Lucerne is relatively complex to introduce into a pastoral management system, and there are considerable risks in its successful adoption. The risks and concerns revealed by the survey and informal interviewing are listed below.

- Establishment failure: Farmers sowing lucerne do not have a guarantee they will successfully produce a crop of lucerne. The chance of failure is greater than most other pasture species. One way to minimise the financial risk of establishing lucerne, and to make up for time a paddock may be out of production, is to sow lucerne with a faster growing crop such as safflower. Farmers following this strategy may have to learn to grow new crops that are more compatible with lucerne (Barker 1992).

- Grazing management: Lucerne requires rotational grazing management. The majority of farms were managed with a regime of set stocking. Wool-producing farms typically run three flocks: ewes, weaners and wethers. Some run an additional flock of maiden ewes. Under the four-paddock rotation system, such a farm would need 12 or 16 paddocks. For farms previously ‘set-stocked’ this implies additional expensive fencing and more dams and reticulation to provide watering points in each paddock. Fencing at this intensity is likely to impede the easy management of cropping activity on the farm.

- Heavier stocking densities. Lucerne pasture is more productive than normal pasture, but wool producers will not make money merely by growing more pasture. More sheep will be required to utilise the extra pasture (Bradslens 1989). The increased flock size will require extra capital, more work in sheep handling and an increased workload of rotational grazing. Higher sheep densities in paddocks may mean a greater need for control of intestinal parasites and increased use of veterinary chemicals or greater attention to rotational grazing systems to minimise parasite infestation (Coffey 1992). These issues are often a major concern for traditional livestock managers.

- Significant changes to farm management systems: One means of maximising the benefit of lucerne is to abandon lambing in autumn in favour of spring lambing. This may mean a need to further re-arrange the farm timetable. Shearing will probably be moved to after the harvest season and before sowing. The risk of grass seed contamination will be higher. Grazing rotation strategies to minimise this risk will be needed. To maximise the benefits of prime lamb production, the farmer will often need to develop new marketing skills and develop relationships with export abattoirs.

- Competition with cropping program: A long standing competitive advantage of the traditional Australian mixed farming system has been the ability to shift the relative balance of cropping and grazing in response to market and seasonal conditions. Perennial pastures reduce this flexibility. Lucerne can imply major changes in crop management. How does the farmer combine the new grazing rotation with the crop rotation side of the business? Whereas an annual pasture may have been grazed for a couple of years before cropping, there are good reasons to maintain a lucerne paddock for its full eight-year life after successful establishment. Consequently, the farmer may have to crop paddocks elsewhere on the farm for a longer period before putting them back into pasture. Forestalling the depletion of soil nitrogen will inevitably mean introducing grain legumes into a rotation system that was predominantly based on wheat and pasture. This will require improved cropping skills, marketing skills and probably investment in cropping machinery.

- Drought risk management: Lucerne will also introduce greater risk into cropping systems. The environmental advantage of lucerne is its ability to remove water from the soil profile to reduce recharge of the watertable. Traditional long fallow crop systems
were successful in minimising risk by conserving soil moisture before a crop phase. Entering a crop phase after drying the soil moisture may increase crop production risk if the following season’s rainfall is below average. Currently in southern Australia climate forecasters are unable to provide useful forecasts to guide phase farming decision-making.

The degree of interest in lucerne was demonstrated by the high degree of enthusiasm for an increased area of lucerne. It was estimated that 36 per cent of the region was suitable for dryland lucerne. Farmers indicated that they would like to see 25 per cent of farm area under lucerne if particular technical and management problems could be overcome. Even at the existing sowing rates, it was estimated the area of lucerne would rise to 11 per cent with no change in the current establishment success rate. Improvements in the establishment success rate to that obtained by the more experienced farmers would see the area of lucerne increase to 17 per cent of the farm area.

A follow up survey in 1996 revealed some contradictory results (Oxley 1997). The overall adoption rate for dryland lucerne increased significantly. The number of farmers sowing more than 5 per cent of their farm area to lucerne rose from 27 per cent to 48 per cent. The average establishment success rate rose from 36 per cent to 60 per cent. However, there was no change in the total area of lucerne in the catchment. While more and more farmers had been sowing lucerne, farmers with existing paddocks of lucerne had been converting them to cropping in response to the more attractive returns from cropping. The obviously successful extension effort to promote the benefits of dryland lucerne had merely managed to maintain the existing area of dryland lucerne.

Since the 1996 survey, there has been a steady increase in the area of lucerne sown in the North Central region, reflecting a gradual improvement in the relative returns to livestock enterprises, particular prime lambs, in comparison to returns to cropping enterprises (Karunaratne & Barr 1999). The benefits of the lucerne extension program of the previous decade are still being reaped. This neatly demonstrates some of the difficulties of evaluating the adoption outcomes of an extension program based upon data from a short time period.

![Graph showing pasture mix area (ha) and number of farmers reporting mixtures of lucerne and other pastures from 1996 to 1999.](image)

*Figure 11 Area of mixed lucerne pasture and adoption of mixed lucerne pasture in the North Central catchment region of Victoria: 1996-99 (Source: ABS)*
A key conclusion is that dryland lucerne will not be adopted over the landscape when it competes with superior cropping returns. Cropping has been a more profitable enterprise for the past decade. The need to generate income overrides any salinity control benefits in this catchment. This perspective is shared by farmers who own land that is being affected by dryland salinity in the Kamarooka area. Interviews with some of these farmers revealed that they recognise the importance of dryland lucerne in wateetable control, but still choose to crop their own land recharge land.

This analysis leads us to the question of future capacity of the farm community in Kamarooka to achieve recharge control. Over the past decade many farmers have gained the necessary managerial skills to give them confidence that they can profit from growing dryland lucerne. There is also a recognition of its recharge benefits. This is potentially one of the most positive success stories in the promotion of the sustainable agricultural practices in Australia. However, while the current relativity of cropping and grazing gross margins remains a factor of farm life, there will be limits to the extent to which lucerne can be expected to cover the Kamarooka landscape. The main motivation for adopting dryland lucerne is its potential for improving the profitability of grazing enterprises. This same profitability motivation will ensure that the needs of the cropping program will generally take precedence over recharge control objectives. Further, there remains a core 30 per cent of landholders who are disinterested in lucerne. This is unlikely to change significantly. Kamarooka is within comfortable commuting distance of Bendigo. Bendigo provides an opportunity for off-farm employment and many farmers in the region have taken this opportunity. The income security this provides reduces the pressure of these farm managers to shift from a traditional grazing system into either dryland lucerne or a cropping system.

Social structure, market structure and sustainability

Full adoption of lucerne in the Kamarooka district would result in a significant increase in the production of prime lambs, and in the production of wool. Local extension staff estimate ****.

We need to ask whether a management intensive salinity control option such as dryland lucerne will be sustainable into the next 100 years? Management intensive farm based strategies are dependent upon a constant agricultural future. The proximity of Kamarooka to Bendigo raises a question about the long-term viability of farming in this region. Currently a number of producers have decided it is not worth the effort of expanding into lucerne. Their off-farm work trajectory means that the set-stocking option of traditional annual pastures is a better lifestyle fit. Kamarooka farmers indicated that land values are higher than can be justified by farming returns. Data from the Victorian Valuer-General supports this contention. Land in Kamarooka is more expensive than similar cropping land a further 20 kilometers or further north. Higher land values could potentially limit the capacity of farm businesses to aggregate properties, leading to decreasing long-term viability. If this is the trajectory of this farming community, it would be likely that the dependence on off-farm income would increase and the pressure to adopt more complex farming systems such as lucerne and cropping will be lessened. This is but one of the potential futures of Kamarooka. There is a minority in the Kamarooka community who believe that within 20 years only three families will farm the district. If this future becomes a reality, and those three family businesses are positive to dryland lucerne, then there is significant potential for further adoption.
Lake Warden: A reason to change

The catchment

The Lake Warden catchment is located to the immediate north of Esperance in West Australia. The main agricultural industries are cropping and grazing. The south west of the catchment is close to Esperance and hobby farming and rural living is a significant land use.

The catchment contains a number of high conservation value wetlands. These are recognised as being of international importance under the Ramsar convention, which requires Australia to protect this habitat.

![Lake Warden Catchment Map](image)

Figure 12 Location of Lake Warden catchment

The farm community

Data on the distribution of farm types and sizes is available from the Australian Agricultural Census (ACC). This data is normally aggregated to the Statistical Local Area. The Lake Warden catchment lies fully within the Esperance Statistical Local Area (SLA). However the catchment occupies only 15 per cent of the agricultural area this SLA. In the 1996/97 the ACC enumerated 351 farm establishments in the SLA. Broadacre cropping was reported on 420 of these establishments. Sheep were reported on 419 establishments and beef on 188 establishments. No other agricultural activity of significance was reported. The SLA appears to be a homogenous mixed broadacre farming area. Data for the SLA is likely to be reasonably representative of most the Lake Warden catchment community. The exception is the area in the south of the Lake Warden catchment which is within commuting distance of Esperance and will have smaller farms than the rest of the catchment.

The ABS estimates farm gross income by calculating a statistic known as “Estimated Value of Agricultural Operations” (EVAO). The median Estimated Value of Agricultural Operations for Esperance SLA and for Australian farms is shown below. Clearly farms in the Esperance SLA are much larger than the Australian average. In 1996/97 the median farm Estimated Value of Agricultural Operations was $363,000. Eighty-five per cent of farm establishments had a gross value of production greater than $100,000. Farms with estimated gross values of production greater than $300,000 managed 75 per cent of the farm area in the SLA. In Lower
Eyre only 40 per cent of farm area was managed by farms of this size and in Greater Bendigo Part B only 13 per cent. It is clear that farms in the catchment are large by national standards and are more likely to be capable of generating surpluses capable of funding land use changes such as conversion from annual to perennial pastures.

The Population and Housing Census provides a better opportunity to examine the family incomes of the Lake Warden catchment community. The Lake Warden catchment lies predominantly within the boundaries of Collector District 5131604. Unlike the first case study of Wanilla, this case study catchment occupies less than half of its collector district. This must be borne in mind as a caveat when we use census data from this collector district to represents the social conditions within the Lake warden catchment.

![Median EVAO Esperance SLA and Australia 1985 to 1997 (Source ABS)](image)

In 1996 the median farm family income was $41,700. Two points stand out from this. First, despite the much larger farms in this region compared to the Lower Eyre Peninsula, there is little difference in the average farm family income of the two areas in this year. This in part reflects a difference in off-farm income strategies. Second, 1996/97 was clearly a year with above average farm performance in the Esperance region. When averaged over the past three censuses, the average income for the region is $32,000 (in 1996 dollars). On average, 33 per cent of farm families had incomes over $50,000. Thirty per cent averaged less than $20,000. These figures paint a picture of an area where farm family incomes are more unevenly distributed than in the Wanilla case study. There are more farm families with high incomes than in Wanilla, and it is likely these are associated with the large businesses which manage 80 per of the landscape. However, there are also a larger number of farm families with low farm family incomes.
Salinity control

Much of the catchment was cleared in the 1960s and 1970s. Significant salinity has developed in a relatively short time. Approximately 8 per cent of the catchment is presently salinised. This includes salinisation of agricultural lands comprising about 2 per cent of the catchment, and salinisation around wetlands in the lower parts of the catchment (comprising about 6 per cent of the catchment (Short et al. 2001)).
The modelling predicts that, with a continuation of current land use and agricultural practice, there will be an expansion in the areas of salinisation on agricultural lands from the current 2 per cent to 27 per cent of the catchment by 2020 and to 45 per cent of the catchment by 2050.

The model was then used to estimate the watertable with current levels of recharge reduced by 50 per cent, 75 per cent and by 90 per cent.

- A 50 per cent reduction in recharge would slow the rate of watertable rise, though it would not lead to any significant decrease in the final extent of salinity. By 2020 this reduction in recharge would leave 6 per cent of the catchment salinised by 2020 and 33 per cent of the catchment by 2050. Most of the land saved from salting in this time would be agricultural rather than wetland environment. This 50 per cent reduction could be achieved by substituting perennial pastures for annual pastures and converting half of the area of cropping land to perennial pastures. This is a major land use change. The economic outcomes of this land use change appear generally positive. Read-Sturgess calculated a modest net gain in income for the catchment over a 50 year period.

- A 75 per cent reduction in recharge would lead to major reductions in the extent of salinity in the catchment, with only 7 per cent influenced by high watertables in 2050. The impact would be achieved across both farmlands and wetlands. A 75 per cent reduction in recharge on farm land could be achieved by replacing all annual pasture with perennial pasture, converting two thirds of crop land to forestry and converting the remaining third of crop land to lucerne-crop phase farming. Read-Sturgess calculated major income losses to farming as a result of this hypothetical land use change. There would be a 25 per cent reduction in farm incomes in comparison to the no-intervention scenario. This is a direct result of the conversion of crop land to forestry.

- A 90 per cent reduction in recharge would stabilise watertables. It would lead to an area of salinisation on agricultural lands of 4 per cent of the catchment by 2020 and 4 per cent
of the catchment by 2050. This recharge reduction could be achieved by conversion of all farm land to forestry production. Read-Sturgess concluded this option would almost eliminate farm incomes across the catchment.

A constrained capacity to change

The “no intervention” scenario presents a picture of significant structural change with the decline of the productive capacity of the agricultural sector. Modelling of changes in farmer population based upon existing adjustment patterns are reported in (Barr 2001). This modelling suggests that by 2020 there would only be a 15 per cent decline in farmer numbers in the Esperance catchment, assuming no change in the existing extent of salinity. When the impact of projected salinity levels is considered, the agricultural sector would need to adjust at a rate which would halve the number of farm operators in the catchment by 2020 if current incomes are to be maintained (see Figure 6). Whilst this decline is similar to that being predicted without salinity in many other rural regions of Australia, it is a major acceleration on that which would be expected without the impact of salinity. With no intervention, there is no doubt that major structural change would occur, but it is clear this would be both unwelcome and painful in comparison to structural change at similar rates in other regions where adjustment will be driven to a greater extent by demographic and lifestyle preference pressures.

The “no intervention” scenario will call upon the capacity of the township of Esperance to change. It is clear there would be significant reductions in the expenditure of the agricultural sector that would have economic impacts on this regional centre. The extent of these impacts could be calculated with a regional input-output model.

![Index of farmer population](image)

**Figure 17** Notional adjustment impacts of salinity control scenarios on the Lake Warden catchment 2000 to 2020

In contrast to the “no intervention” scenario, the **50 per cent recharge reduction scenario** demonstrates the benefits of slowing the rate of structural adjustment caused by salinity.
Whilst this scenario has little impact on the final extent of salinity damage, it significantly extends the time over which this damage accumulates. The rate of adjustment likely till 2020 is halved. From the point of view of the current generation, there are benefits to be captured by halving the rate of recharge. The achievement of a 50 per cent recharge reduction is dependent upon both the conversion of annual pastures to perennial pastures and the conversion of half of the existing cropland to perennial pasture. Adoption studies elsewhere in Western Australia present a sobering picture of the extent of implementation of perennial pasture based salinity control measures on farms (Bathgate & Pannell 2000; Kington & Pannell 1999). These studies suggest farmers in the West Australian wheat belt have high knowledge of dryland salinity and its treatment, the rates of adoption of perennial pastures are low compared to that recommended by hydrologists. Further, farmers’ expectations of these low rates of sowing on recharge control are overoptimistic. The Lake Warden catchment presents a possibly best case scenario for the adoption of perennial pastures.

- The economic analysis suggests the adoption may be marginally more profitable than status quo.
- The extent of salinity is progressing rapidly, even by West Australian standards, providing a focus on the problem.
- The Lake Warden catchment hydro-geology is responsive, providing relatively fast feedback to farmers of the impact of salinity control measures.

Limited evidence available suggests there is significant potential to achieve much of this change. First, the farms of this region are much larger than the national average and are far more likely to be capable of capturing productivity gains over the next 20 years. Second, unlike an area like Kamarooka, there is little doubt the Lake Warden region will remain agricultural over the foreseeable future. The major hurdle to the implementation of the 50 per cent reduction is the conversion of 50 per cent of cropland to perennial pastures. The extent of this conversion is likely to be mediated by the relative returns from cropping and livestock enterprises. At the time of writing grazing enterprises are providing high returns in comparison to the past decade. Despite this, returns from cropping are still seen as superior to grazing. A switch from annual to perennial pastures and from cropping to perennial pastures significantly reduces mixed farm flexibility. It also introduces management challenges which remain to be resolved. Currently the Esperance office of the Department of Agriculture is recommending farmers maintain no more than 40 per cent of their pastures as kikuyu. Greater than 40 per cent may introduce problems of pasture management during spring when grazing pressures are required. This highlights the issue of technical support as an incentive for land use change. Land use change is more likely to occur when supported by research to minimise the perceive risk of the adoption of more complex management systems (Marsh 1999; Pannell 1999).

The 75 per cent recharge reduction scenario would achieve a major reduction in the impact of salinity on both the farm and environmental assets of the catchment. However, this scenario requires a conversion of two thirds of cropped land to forestry based upon Maritime Pine. The conversion to forestry is unprofitable and leads to a 25 per cent reduction in the farm profit over a 50 year period in comparison with living with the salt. Without significant subsidy, the impact of this land use change option is to bring forward adjustment pressure on the Lake Warden farm community. This is a result of the high establishment costs and the 32 year harvest rotation. The notional impact of this shift is indicated in Error! Reference source not found.. To compensate for the financial losses experienced over a 20 year period, the community would need to adjust at a significantly greater rate than required for the “live with salt” scenario. It is clear the community will not be capable of implementing this scenario within its own resources.
The 90 per cent recharge reduction scenario requires conversion of the current farm landscape to forestry. Major conversions of landscape to forestry have occurred in selected farm landscapes across Australia. What these landscapes have in common is the capacity to support a profitable plantation forestry industry. In most cases this prospect has allowed forestry companies to purchase land at a substantial premium over its value for traditional agricultural uses. Thus, despite local opposition to the impacts on local communities, there has generally been little difficulty in finding willing vendors. Lake Warden is not one of these catchments. Low rainfall means forestry based upon Maritime Pine is unprofitable, and widespread plantation establishment is likely to result in the elimination of farm income from the catchment in a very short period. This is a clear case of the cure being worse than the disease. This would necessarily lead to a major population loss.

Conclusion

The 50 per cent recharge reduction option is potentially within the capacity of the Lake Warden farm community. The chances of implementation can be enhanced by research and extension support which reduces the risks of adoption through improving understanding of the management implications, improved perennial pasture species and the development of salt land agronomy options. This option does not reduce the final extent of salinity, but buys maybe an additional generation within which to adjust to the new landscape. The reduction of salinity impacts upon the important downstream wetlands in this catchment is beyond the capacity of current landholders. Protection of the wetlands will be a wider community responsibility. Whilst the estimates of community willingness to pay for this protection suggest there will be community capacity to protect these wetlands, it is not clear yet that we have the capacity to judge which is the most appropriate means of protecting the wetlands.
Upper Billabong Creek: The value of research

The Upper Billabong Creek catchment is an unexpected piece of positive news in the development of the four National Land and water Resources Audit case studies. The Upper Billabong Creek is centred on the southern NSW town of Holbrook. Upper Billabong Creek was chosen as a case study on the basis that it was located upstream of a gauging station that was showing rapidly increasing salinity. The catchment was also in a high rainfall area that significantly increased the options for watertable control using forestry.

![Figure 18 Location of Upper Billabong Creek catchment](image)

The detailed hydrogeological modelling undertaken for the case study concluded:

> Waterlogging rather than salinity is the major issues in much of the catchment, and saline discharge into streams from a shallow salt store has been identified as a major issue in the lower catchment. This saline discharge, while important locally in terms of stream degradation of Simmons and Kangaroo Creeks, has limited downstream impact due to the overall flow from Billabong Creek. (Baker et al. 2001)

In other words, the salinity problem envisaged in this region appears on further research to be much smaller and less threatening than was perhaps anticipated. There is no need for massive landscape change to minimise salinity impacts from this catchment downstream or to protect land within the catchment.

In one sense, the case study appears rather trite when viewed in the context of questions of capacity to change being asked of the Lake Warden or Vanilla case study catchment communities. However, the case study does suggest a very important message. Given the scale of the nation’s dryland salinity problem, it is clear there will never be sufficient resources to meet all the full cost of dryland salinity control. Salinity policy over the past decade has often been based upon what have been called “best bet” options. Billabong Creek is no exception. A quick search of the web will find a number of press releases that argue it is time to test on-ground solutions rather than investigate the causes of salinity within the catchment. These conclusions are justified by claims such as those recently made of the Billabong Creek catchment:
“We have developed a good understanding of what’s causing issues like dryland salinity.”
(DLWC 2001)

Not only has Billabong Creek been chosen as a case study for the National Land and Water Resources Audit, but it is a focus catchment in both the Murray Darling Basin “LandMark” project and the CSIRO initiated “Heartlands” program. The former aims to test the sustainability of existing farming practices. The latter aims to design and achieve socially acceptable land use change. Perhaps there is no real need for significant land use change to address salinity? Given the scale of problems being experienced in catchments such as Lake Warden, the expenditure of limited salinity funds upon landscape change to address this minor problem is a less than optimal resource allocation. The findings of the Upper Billabong Creek study are perhaps the most important lesson from the salinity case studies. Where our capacity to judge the effectiveness of our salinity control options is limited, we should act cautiously. It is not always time for “works on the ground”.
Conclusions

The outcomes of both biophysical and economic modeling have changed the fundamental appreciation of the policy issues in each case study area. We now better appreciate the limits of our power to respond to salinity. There are some powerful lessons to be gained from this combined study. The first four of these recommendations relate to the appropriateness of proposed salinity control investments. Perhaps the most important aspect of “capacity to change” is our capacity as a community to make collective decisions about salinity management. The final five recommendations concern our methods of decision making within integrated catchment management frameworks.

- **There is no simple broadly applicable paradigm with which to conceive our responses to salinity.** The wide variation in the situations of these four case studies makes clear the dangers of assuming the solutions for one area can be transferred to another region without careful consideration of the unique characteristics of the region. The strategies for the Lake Warden catchment, with it’s predictions of major salinity expansion and landscape occupation by large farms are not appropriate for the other three case studies with their less serious prognoses and smaller farms. The prescriptions of “do very little” for Vanilla and Upper Billabong are a result of differing justifications. In the Vanilla, the cure is socially and economically worse than the disease. In Upper Billabong, there appears to be little or no disease. Further scenarios investigated as part of the National Land and Water Resources Audit West Australian Implementation Project presented further variation (Campbell et al. 2000). Socio-economic assessment of salinity control using oil Malley plantations in Woodanilling suggested the policy would be highly unprofitable. Maritime Pine plantations at Boscabel appeared marginally profitable. Blue Gum plantations in the Upper Kent appeared quite profitable (van Bueren, Pannell, & Hodgson 2000).

- **Expectations of farm based change leading to salinity control need to be tempered.** In the two of the case study regions which face an expanding salinity problem, is clear there is a limited capacity in the farm community to control salinity. This is not because the farm community is incapable of making significant changes to the ways in which they manage their land, but because the scale of change required is incompatible with existing farming systems. Historical evidence is that the farm community is capable of significant structural change, given time, and that this is the most likely response to salinity in many communities. Land use change within existing farming systems is likely to buy time in which this adjustment can occur.

- **Broad scale reforestation proposals will often be poor investments from an economic and social perspective.** Despite our initial conclusion that there are dangers in transferring catchment management prescriptions from one catchment and applying them in other catchments, some general observations can be made about the place of broad-scale forestry for salinity control. There is a growing body of evidence that broad scale reforestation will generally incur major economic and social costs. The watertable control benefits will be many decades or even centuries in coming, and in the short to medium term loss of runoff from reforested areas may worsen in stream environmental conditions (Bell & Beare 2000; Bell, Mues, & Beare 2000; Heaney, Beare, & Bell 2000; Madden et al. 2000; Read Sturgess and Associates 2001; van Bueren, Pannell, & Hodgson 2000).

- **A lack of profitable technically feasible options is the major constraint to the capacity to control salinity.** Without new farming systems that offer both reduced leakage and improved profitability, there is unlikely to be any major change of farming landscapes
within this generation which will lead to reduced recharge of watertables. Investment in the development of new farming systems is one response to this situation. However, we must accept that it offers gurantee of a panacea for all salinity-affected landscapes. Learning to live with salt is an inevitability for many landscapes.

- **The major issue of “capacity for change” is the capacity of our community to make informed decisions about investment in salinity control.** The biophysical and economic analysis conducted in these case studies has demonstrated the clear value of improved information to underpin the policy making process. This is most obvious in the Upper Billabong case study where a best bet approach combined with very limited monitoring information could potentially lead to salinity control investment which offered far lesser returns than investment in other landscapes. In the Lake Warden case study the analysis has revealed that dependence upon incremental change to existing farming systems will provide no protection to the lower catchment wetlands. However, Read-Sturgess in their report on the economics of salinity control emphasise that there is incomplete information on the opportunities for engineering protection of these wetlands. They argue it is premature to make decisions about public investment in recharge control using plantation forestry. In Kamarooka we have learnt that there will be little further expansion of salt and that farm based solutions can eventually overcome the existing salinity problem. The obvious question is whether we have a similar level of understanding in key catchments beyond the case study areas and whether we need such deeper understanding. There is clearly a significant cost in gaining such information about the behaviour of groundwater systems. Given the potentially enormous economic and social costs of some proposals for land use change, the cost of improved information and understanding will be relatively small in comparison.

- **We need to re-engineer our integrated catchment management structures to operate within an adaptive management framework.** The bio-physical and economic modeling of the case studies has presented an understanding of salinity which is at odds with some widely-held conceptions of the nature of the salinity problems we face. This situation has arisen in part because of the growing awareness of dryland salinity over the past two decades, well meaning education of the wider community and a natural desire to act sooner rather than later to solve the problem. During this period there has been a fundamental improvement in our scientific capacity to understand the biophysical nature of dryland salinity. The availability of computing power, software modeling tools and remote sensing capacity has increased astonishingly since the first salinity management plans were developed in Victoria and West Australia in the 1980s. It was inevitable that these tools would change our understanding of dryland salinity in a way that has fundamental implications for catchment management. Just as current understandings have proved some previous understandings of our capacity to control salinity to be ill-founded, so future new understandings will cause us to re-assess some of our current understandings. Catchment planning will therefore be on-going. We will never have the definite plan, because we will never fully understand the problems we face. Catchment planning makes sense if we conceive it as adaptive management. On-ground works need to be seen as experiments, and investment in on-ground works needs to be seen as inseparable from investment in monitoring and evaluation. It is not clear that this view of catchment planning is shared across our catchment management bodies (Marshall 2001).

- **Investment in salinity control should be based upon a triage model.** The scale and costs of land use change required to limit the growth of dryland salinity make it clear that a policy response to salinity needs to be based upon a triage model. In a triage model, investment in salinity control would be targeted at situations where the investment is most likely to reap a return to the community. Situations where the salinity situation offers poor chances of recovery, or where the impact of the salinity has relatively low impacts would be allocated a lower investment priority. The triage model contrasts with proposals for massive expenditure on broad scale reforestation of our catchments.
(Virtual Consulting Group & Griffin nrm Pty.Ltd. 2000). Such proposals are based upon observed total costs of salinity control and very limited information of both the efficacy of such measures and the full economic and social costs of their implementation.

- A “works on the ground now” imperative should be tempered by a “least regrets” investment approach. The funding of natural resource management initiatives can sometimes have multi-functional economic, social and political objectives. This can be a legitimate political and social strategy. Analysis of investment proposals on the basis of salinity outcomes alone can overlook the subtleties of such situations. This situation can arise where there is a pressure for “works on the ground” but there is a limited scientific understanding of the potential ameliorative impacts of those works. Catchment groups operating in such an environment would be well advised to adopt a “least-regrets” strategy in making investment decisions. If we cannot be confident of salinity benefits in 10 or 20 years time, then a sustainable funding framework for natural resource management in general needs to be able to demonstrate other environmental benefits. These might be in improved water quality, biodiversity or regional economic sustainability.

- Landscape change must be seen as a multi-generational challenge. Implementation of landscape change for salinity control within one generation will generally impose enormous costs upon either existing landholders or the wider community. Even if implemented despite these costs, the salinity benefits of landscape change will in many situations not be gained for several further generations. The largest of these costs is often the opportunity cost of removing land from current agricultural uses. In some regions there is a chance these opportunity costs will change with time in response to changing social conditions and commodity prices. The removal of land from agriculture is a long-term trend generally associated with economic development (Mather, Fairbairn, & Needle 1999; Rutel 1998). It is this long term change in land use driven by social and economic change which perhaps offers the only means of achieving wide scale reforestation of some catchments.
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