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Dryland salinity in the Upper Kent River catchment of Western Australia: farmer perceptions and practices

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Abstract. Dryland salinity, resulting from extensive land clearing, has been increasingly recognised as a serious environmental and economic problem in Western Australia. Policy initiatives at the state and national level in Australia have attempted to influence farmers' choices of land management practices to reduce the threat of salinity. This study examines, for a particular catchment, what farmers' salinity management practices have been and are likely to be, how farmers view the salinity problem and its recommended treatments, and farmers' perceptions of why the salinity problem continues to worsen. We found that the farmers had high levels of knowledge about salinity and its treatment, although their perceptions appeared to be overly optimistic on a number of aspects of the problem. As a group they were highly uncertain about its extent and the rate of worsening, and they highlighted the complexity, modest effectiveness and relatively poor economic performance of available treatment options. It appears that the scale of salinity prevention practices in the catchment is insufficient for preventing ongoing increases in the area of saline land.

Additional keywords: public policy, agriculture, land conservation, social survey.

Introduction

Dryland salinity is considered to be among the most serious environmental problems in Australia (Prime Minister's Science, Engineering and Innovation Council 1998). Ferdowsian *et al.* (1996) estimated that the area of agricultural land in Western Australia affected by salinity (defined as land on which wheat yield would be reduced by 50% or more) was 1.8 million ha in 1994 (approaching 10% of the total area of cleared agricultural land). Using a different method, the National Land and Water Resources Audit (2001) estimated that the area of all land 'at risk' [defined as land with a groundwater table either (i) less than 2 m from the surface or (ii) between 2 and 5 m and rising] in Western Australia is currently 4.4 million ha and will be 8.8 million ha by 2050. The proportion of salt-affected agricultural land in Western Australia may exceed 30% within the next 50–100 years (Short and McConnell 2001). Of the 6 Australian states, Western Australia has by far the greatest area at risk, with 80% of the current national total, and 50% of the 2050 forecast area (National Land and Water Resources Audit 2001).

Within the current policy framework, prevention of this dramatic worsening is substantially dependent on farmers voluntarily changing their farming practices away from a system based almost solely on annual plant species, towards much greater use of perennial plant species (e.g. Anon. 1996). Even though rainfall for much of the region is low (ranging from less than 300–800 mm/year), enough water evades capture and transpiration by annual crops and pastures to cause naturally saline ground waters to rise steadily in most of the region. A change to perennial species would reduce or eliminate this process of ground water rise.

Although this is well understood and widely discussed, the adoption by farmers of perennial species has been, in most districts, at a scale that is a small fraction of that recommended by hydrologists for prevention of salinity (Hatton and Nulsen 1998). Various reasons for this have been proposed [e.g. see Barr and Cary (1984), Hooper (1995) and Pannell (2001*a*) for discussion directly related to salinity, or see Sinden and King (1990), Wilkinson and Cary (1992), Barr (1999) and Pannell (1999) for more general discussions of adoption of land conservation practices]. Surprisingly, however, there has been no rigorous study of where Western Australian farmers stand on the salinity issue [there have been some studies of this type conducted in eastern Australia (e.g. Barr and Cary 1984; Barr *et al.* 2000; Curtis *et al.* 2000) but these are considered of limited relevance to Western Australia due to differences in the nature of the salinity problem (irrigated *v.* dryland) or farming systems]. How much of a threat do they perceive dryland salinity to be? How effective do they perceive the available salinity management options to be? What are the other advantages and

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disadvantages of these options? Which of the management options are being adopted and to what extent? These are the questions addressed in this study, which focuses on the Upper Kent River catchment near the south coast of Western Australia. This catchment is of substantial community interest because of its importance as a potential source of potable water.

In the next section, we provide background about the catchment, its farms and farmers. This is followed by an outline of the development and application of the survey instrument used. Results of the survey are presented and discussed, and we conclude with an outline of the key implications of the study.

Materials and mehods

The Upper Kent River catchment

The Kent River (Fig. 1) was selected as a future potable water supply catchment in the late 1970s. The lower catchment remains mainly forested and has no significant salinity problem. The predominantly cleared upper catchment contains about 120 farm businesses. Most land is held as a freehold title and some has been farmed since the beginning of European settlement. Farms in the catchment were legally prevented from further clearing in 1978, and compensated financially for this by the state government.

The main agricultural products of the catchment are wool from sheep grazing annual pastures and a range of annual crops. The region has a relatively high annual rainfall for Western Australia (500–750 mm) and parts of it are suitable for profitable production of tree species, principally *Eucalyptus globulus*, which is processed to wood chips used in paper manufacture. This availability of a profitable tree-based enterprise distinguishes the catchment from many parts of the agricultural region of Western Australia, for which rainfall is too low to support wood-producing industries. In most other agricultural catchments in Western Australia, revegetation with trees is likely to be viewed more negatively by farmers than it is in this catchment. In addition, the catchment is more suitable for production of perennial pastures than are most other farming areas of Western Australia.

The Upper Kent became a ‘focus catchment’ in the National Dryland Salinity Program from 1992 to 1997, and in 1996 was declared a ‘focus recovery catchment’ within the Western Australian Salinity Action Plan, qualifying it for further financial assistance, extension and scientific research to foster changed farming practices. A state government agency, The Water and Rivers Commission, is subsidising farmer implementation of salinity prevention measures in a small number of catchments (including the Kent) at a rate of A$2.5 million per year (Anon. 1996). Despite this attention, land conservation activities in the catchment had not been formally monitored except in a small telephone survey in 1995.

The survey

The survey included a mixture of quantitative and qualitative questions, including open-ended questions. The specific design of questions was based on recommendations of Foddy (1994). The draft survey instrument was reviewed by researchers with experience in social surveying techniques and by others who had local knowledge of the region. The survey was then pre-tested on a subsample of the farmers with the assistance of the Kent River Land Conservation

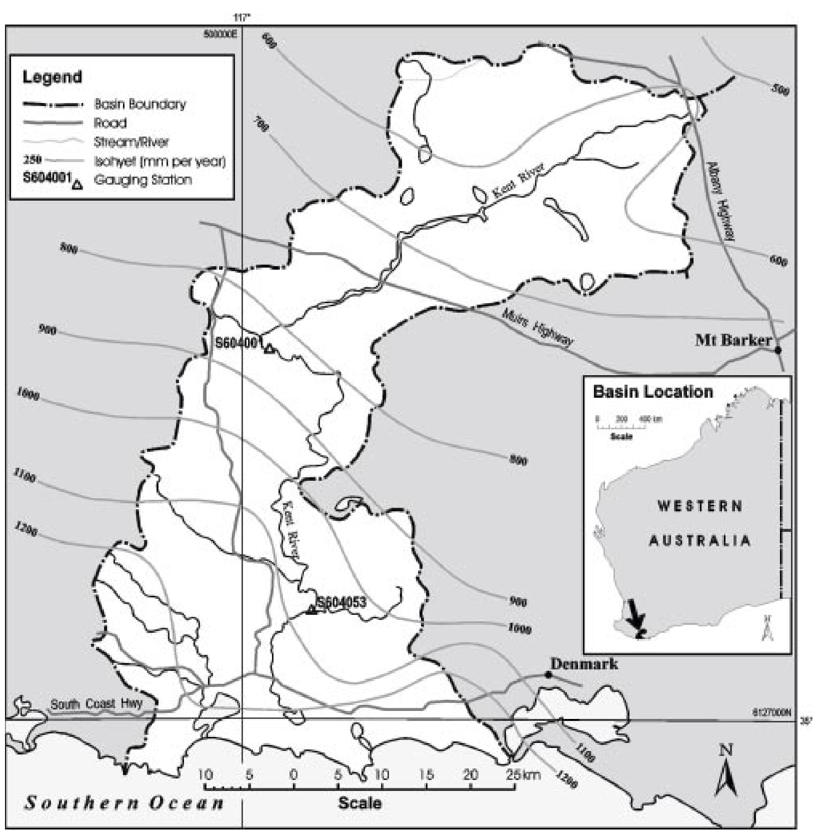

Figure 1. Map of the Kent River catchment (diagram provided courtesy of Water and Rivers Commission).

District Committee (LCDC). The completed instrument was administered as a mail survey, sent with stamped addressed envelopes and a covering letter to all farmers in the catchment in May 1997. Follow-up telephone calls were carried out in August after a follow-up letter in July. A total of 69 surveys were returned, representing about 53% of Upper Kent River catchment properties. This covered 77 600 ha out of a total of 112 800 ha, representing over 69% of the Upper Kent River catchment area. The survey instrument is available in Kington (2000).

Results and discussion

General characteristics of farms and farmers

By 1997, up to 30 original farm property locations in the Upper Kent River catchment had been leased or sold to tree plantation companies, representing about 10% of the upper catchment area, and more sales were expected. In the previous 2 years, at least 5 properties had changed hands. Farm size ranged between 40 and 5066 ha, with an average of 1134 ha. Present landholders in the catchment area acquired their land as early as 1907 or as recently as 1996, but on average had held the property for 30 years. Landholders had expanded their land holdings over the years to maintain viable farm businesses.

Land clearing

Table 1 shows the year by which half of land on each farm had been cleared. The average was 1957, but results ranged from the 1920s to the 1970s. In 1978, bans on further clearing of native vegetation were imposed over the whole catchment to protect future potable water supplies from salinisation. As a result, the majority of perennial vegetation in the upper catchment is in the form of native remnants (Strawbridge 1997). Vegetation surveys indicate that 36% of the Upper Kent River catchment remains covered with remnant native vegetation. Thus, the total area of the upper catchment devoted to perennial plants (including remnant native vegetation) is of a similar magnitude to that identified as necessary within the state's Salinity Action Plan. However, the spatial distribution of the perennials is such that it is only partially effective for salinity prevention. Moreover, farmers have not fully protected their native remnants from degradation (largely through grazing); only about 21% of the catchment has intact native vegatation (Strawbridge 1997). The other remnants are scattered (4%) or modified (11%), and contribute to ground water recharge (R. Ferdowsian pers. comm. 1997) so that they are not effective in preventing salinity. This non-protection of remnants may be partly a reflection of the farmers' strong opposition and political resistance to the original imposition of clearing bans, but in the context of current knowledge, it seems highly ill-advised.

Table 1. Timing of land clearing in the Upper Kent River catchment

Decade when 50% of farm land cleared	Absolute frequency in survey sample
1920–29	1
1930–39	0
1940–49	3
1950–59	24
1960–69	14
1970–79	11
1980–89	0
Total	53

Farm inheritance

Forty per cent of respondents said that their children would inherit the farm property, while 30% answered 'maybe'. Fifteen per cent said that their children would not inherit the farm because, for example, the children did not want to become farmers, or the property was not considered financially viable. Twelve per cent did not yet know. The lack of clear inheritance plans by 60% of farmers may prompt concerns about their incentives for land conservation. It is interesting that Barr *et al.* (2000) also concluded that many farmers in parts of the Murray–Darling Basin are 'on a trajectory out of agriculture', although the causes would be somewhat different in the 2 regions.

Involvement in land conservation

Attendance at 'landcare' meetings and field days was high. The National Landcare Program is a nationally funded program encouraging and supporting farmers in their land conservation practices. Within the Australian farming community, the term 'landcare' has come to mean land conservation in general. It will be used in this paper in this more general sense. Eighty-one per cent of upper catchment landholders attended a land conservation meeting in 1996 and 67% attended at least 1 'field day' (viewing of experiment or treatment results in the field) during 1996. Twenty-one per cent of farmers had attended 5 or more Landcare events during 1996, and 4% had attended more than 10. There was no relationship between area of saline land and the farmer's frequency of attendance at landcare meetings (see Fig. 2). However, Table 2 shows that there was a positive relationship between attendance at land conservation meetings and plans to implement land conservation practices.

Dryland salinity

The perceived extent of dryland salinity varied widely between Upper Kent River catchment farms (see Table 3). Farmer respondents believed that secondary dryland salinity (i.e. new salinity resulting from land clearing) was affecting, on average, 5% of their farm area. Of this sample, 79% of farmers perceived that salinity was affecting 5% or less of their land. In contrast, government hydrologists estimate that about 20% of the Upper Kent River catchment is currently affected by dryland salinity (Ferdowsian *et al.* 1996).

Landholders were asked whether they believed that dryland salinity would increase on their farms in the future.

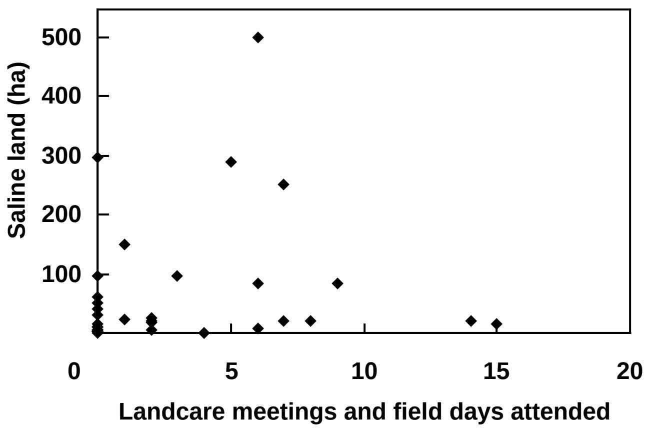

Figure 2. Area of saline land on a property and farmer attendance at land conservation meetings and field days during 1996.

Opinion was divided over this question (Table 4). This might suggest (i) that farms are not equally affected by salinity, (ii) that farmers are having different success rates with remedial measures, or (iii) that there are differences in knowledge among farmers. Indeed, current forecasts by hydrologists (Ferdowsian *et al.* 1996; Campbell *et al.* 2000) are that most of these farmers face significant increases in the area of saline land on their farms. The difference between this forecast and the perceptions of about half the farmers is striking. It may be partly because of an unusually dry 3-year period before the survey.

Waterlogging

Waterlogging is related to dryland salinity in that they both result from excess water, and the lower plant productivity that waterlogging induces allows more water to escape transpiration by plants and to drain into the saline watertable. Waterlogging also interacts with salinity, making plants less able to screen out salt at the root surface, thereby making them more susceptible to salinity damage (Barrett-Lennard 1986). Only 6% of respondents claimed to be free of waterlogged soils on their property. Forty per cent of farmers rated their incidence of waterlogging to be greater than 'isolated patches', while 3% indicated 'about half' and none selected 'most areas'. These perceptions also contrast with opinions of local hydrologists. For example, Ferdowsian and Ryder (1997) estimated that nearly 3 quarters of the Upper Kent River catchment soils are annually affected by winter waterlogging.

Table 3. Frequency distribution of the percentage of saline land on farms

Percentage of saline land	Frequency
0	1
5	29
10	3
20	5
30	0
40	0
50	1

Farm-to-farm externalities

A feature of dryland salinity is its potential to cross farm boundaries. Farmers are aware that they may be affecting, or affected by, their neighbours. Although it has recently been argued that the extent of such spill-over effects in Western Australia has been overstated in the past (Pannell *et al.* 2001), to the extent that they do occur, management of dryland salinity may require a degree of cooperation and coordination between neighbours.

Thirty-three per cent of the sample of farmers thought that they were both receiving salinity, and contributing it to other properties. Sixty-two per cent believed that they were adversely affected by their neighbours, but only 34% acknowledged that they were affecting their neighbours. It is not clear whether this interesting contradiction reflects sample bias or a biased tendency for the respondents to judge themselves more favourably than their neighbours, but the latter appears more likely. Consistent with Pannell *et al.* (2001), local hydrologists believe that the farmers' responses to this question tend to over-rate the extent of farm-to-farm salinity impacts (R. Ferdowsian, pers. comm.).

Farmer knowledge of available management options

The respondents were asked to list possible methods for managing dryland salinity and waterlogging They revealed very good knowledge of the available management options. Suggested practices included the following:

(i) installation of drainage followed by tree planting (the most common response);

Table 2. Farmer attendance at Landcare meetings during 1996 and plans for future land conservation activities

'Yes' means the farmer attended at least one meeting, or indicated plans to implement *any* further land conservation measures in future.

Landcare meetings	Plans to implement further land conservation measures in future?			
	Yes	No	Don't know	Total
Yes	24	1	2	27
No	16	7	0	23
No response	6	7	0	13
Total	46	15	2	63

Table 4. Farmers' predicted change in saline area on their own farms 5 years after survey

Predicted direction of change in saline area in 5 years time	Respondents (%)
Increased	46
No change	25
Decreased	21
Don't know	9

(ii) fencing, stock removal and revegetation of all watercourses and affected land (for salinity);

(iii) contour drainage with revegetation (for waterlogging);

(iv) perennial pastures and deep-rooted vegetation;

(v) drainage of water into main waterways; pumping saline ground water to the ocean (1 response);

(vi) re-positioning of watercourses back to their original drainage lines (1 response);

(vii) minimum tillage;

(viii) application of gypsum to the soil;

(ix) use of early season crops, which may use more water than traditional crops; and

(x) re-specification of farm boundaries.

Several farmers stated that strategically placed plantings of trees or tree belts would be sufficient to manage salinity on their farm. A few individuals felt that the only way salinity would be removed was if all land was returned to trees. Only 2 respondents felt that no amount of change on their properties would prevent the onset of dryland salinity. Overall, an optimistic view of the problem still exists amongst the catchment community farmers. The degree of optimism is inconsistent with hydrologist opinion and with recent empirical evidence and computer modelling (e.g. George *et al.* 1999*a*, 1999*b*; Campbell *et al.* 2000).

Farmer implementation of management options

Only 3% of landholders had not implemented any land conservation practices on their properties (see Table 5). At the other extreme, 10% of respondents reported that they had revegetated more than 200 ha. Over half had revegetated more than 10 ha and one-third had installed more than 5 km

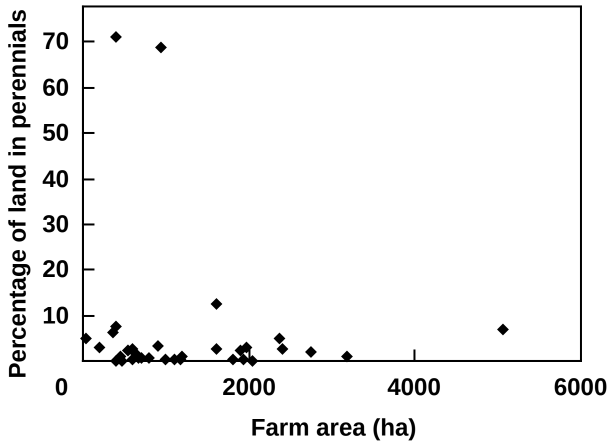

Figure 3. Relationship between farm area and percentage of farm established to trees or perennial pasture.

of drains. There was no apparent relationship between the area of the farm and the percentage of the farm on which perennials had been established (Fig. 3). As noted earlier, only a small minority of farmers expressed the opinion that control of salinity is not achievable without radical changes in land use to include large areas of perennial species. Hydrologists, on the other hand, believe that large areas will need to be converted to perennials to reduce or even maintain current areas of salinity (Hatton and Nulsen 1999).

Table 6 shows that the most-widely adopted land conservation practice was drainage (mainly shallow drains for surface-water management). Tree planting was clearly more popular than perennial pasture, reflecting economic returns from the 2 options. Use of salt-tolerant plants is partly about land conservation and partly about making use of degraded land. Fencing is a necessary compliment to planting of trees or salt-tolerant species, to manage stock grazing, but it also has benefits such as allowing the regeneration of native perennial vegetation.

Considering the tree plantings in more detail, the 2447 ha of trees planted by respondents since 1984 include 1527 ha of commercial bluegum plantations, 797 ha of tree belts, and 124 ha of trees incorporated as part of alley-farming systems. There is no correlation between the area of tree

Table 5. Percentage of farmers implementing revegetation and drainage in the Upper Kent River catchment

Drainage (km)	Area of revegetation (ha) 0 ha	1–10 ha	11–50 ha	51–200 ha	>200 ha	Total
0	3.0	11.9	7.5	6.0	1.5	29.9
1–5	11.9	10.4	9.0	4.5	1.5	37.3
6–10	3.0	0.0	3.0	1.5	6.0	13.4
11–20	4.5	1.5	9.0	1.5	1.5	17.9
>20	0	0	0	1.5	0	1.5
Total	22.4	23.9	28.4	14.9	10.4	100.0

Table 6. Salinity management already implemented in the Upper Kent River catchment

Treatment	Farmers adopting treatment to any extent (%)
Tree planting	66
Drainage	77
Perennial pasture	20
Fencing	69
Salt tolerant species	62

planting and the area of saline land on individual properties (Fig. 4). There is similarly no correlation when these variables are expressed as percentages of the total farm area (graph not shown). This may be because the prime motivation for tree planting is commercial production, rather than salinity prevention. It may also be due in part to a confounding of influences: greater areas of saline land might tend to prompt greater planting of trees, while greater planting of trees would be expected to reduce the area of saline land.

A similar absence of correlation exists between length of drainage installed and area of saline land (Fig. 5). Nevertheless, 77% of respondents had implemented drainage of some sort, averaging 8.5 km. These are likely to be of benefit in managing surface waters but, interestingly, almost 50 km of deep drainage (trenches dug to a depth of 2 m or more) had been installed, despite evidence that it has limited ability to control ground waters (Speed and Simons 1992; Ferdowsian *et al.* 1997).

Adoption of landcare practices has increased considerably over the last 2 years (Table 7). Seventy-three per cent of survey respondents said they planned to implement new land conservation measures on their properties in the near future. Of the 24% who said they would not be making future investments in this area, some pointed to a lack of finances, and some to uncertainty caused by native title claims over their land as presenting major obstacles.

Impacts of farmer land conservation action

Table 8 shows the proportion of respondents implementing land conservation practices who reported observing a resulting benefit. In general, 50% or less of those investing in land conservation had been able to detect benefits (although some believed that it was too early to tell).

The benefits reported varied widely, but included the following:

(i) *Drainage*: increased productivity from cropping; greater control of water flow; full dams; less water in low-lying drained areas; reductions in waterlogging and soil erosion.

(ii) *Fencing*: increased growth and the return of native species; better management of stock; revegetation of previously bare and eroding soil; provision of summer fodder during drought times.

(iii) *Perennial pastures*: reductions in soil waterlogging.

(iv) *Trees*: using excess water; providing winter shelter for stock; reduced waterlogging; lower ground water levels; reduced wind erosion; aesthetic improvements.

(v) *Salt-tolerant species*: restore otherwise-bare saline land; a more drought-proof property; improved quality of grazing.

Table 9 shows overall perceptions of recent changes in a number of land quality indicators. The most common response was 'no change' apart from for ground water level, for which 'don't know' predominated. This suggests that a minority of farmers were monitoring piezometers on their properties, which is consistent with anecdotal evidence for most agricultural regions in Western Australia [Marsh *et al.* (2001) documented 1 of the few regions which provided an exception to this general observation]. The lack of monitoring is remarkable, given the extent of the salinity problem faced and the fact that this particular catchment has been the target for so much attention in government programs encouraging salinity-management practices. Only 6 landholders claimed that groundwater levels beneath their properties had lowered over the last 5 years. These properties have revegetated an average of 226 ha of land to trees, and

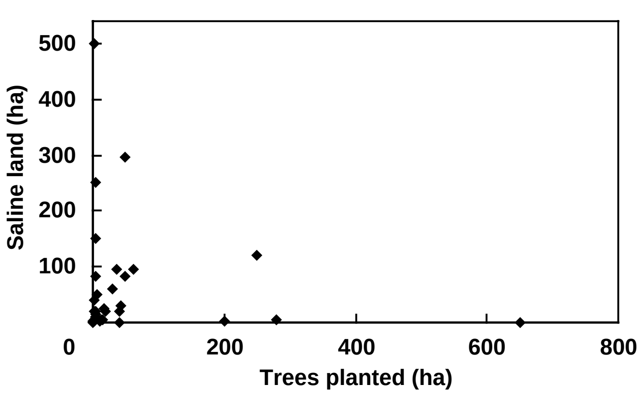

Figure 4. Area of trees planted and area of saline land.

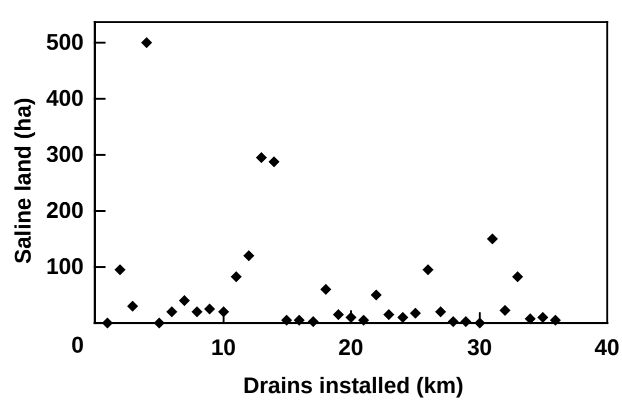

Figure 5. Length of drainage installed and area of saline land.

Table 7. Adoption of land conservation practices in 1995 and 1997 (% of farmers adopting to any extent)

Year	Trees	Drains	Fencing	Perennial pasture	Salt-tolerant species
1995	46	44	30	17	—[A]
1997	66	77	69	20	62

[A]In 1995 no data were collected on planting of salt-tolerant species.

installed an average of 9 km of drainage (compared with the sample average of 55 ha and 8.5 km).

Causes of the salinity problem

In response to a direct question, most farmers (85%) agreed that dryland salinity is a 'major environmental problem.' We note the interesting juxtaposition of this result with the findings that they generally under-rate its extent and over-rate the effectiveness of treatments.

The farmers were asked why salinity continued to be a major environmental problem despite ongoing government attempts to address it. Farmers recognised a variety of underlying socio-economic and technical causes contributing to the difficulty of treating dryland salinity. They were offered a range of reasons drawn from previous focussed discussions with farmers in the catchment, and asked whether they agreed that each proposed reason was a cause for the continuing problem. Table 10 shows that the reason most frequently agreed with was that no quick and easy solutions exist. Other similar reasons (it is too big to fix, it is too uneconomic to fix, there is no spare time available for landcare) were also rated highly. The 2 other reasons most identified by farmers were that there is too much uncertainty (e.g. about future salinity levels, about impacts of treatments, about future prices) and government restrictions on drainage (which are designed to protect the Kent River from salinisation). Only a small minority concurred with scientist/hydrologist opinions that drainage, although important, is far from sufficient, and needs to be used to complement large areas of perennial vegetation.

Despite the recognition of salinity as a serious concern, the survey reveals a contrast between what farmers think will fix the problem and what they have actually implemented. The gaps between actual levels of treatment implementation and those deemed necessary by hydrologists are even greater. Most farmers have adopted only small changes, such as the siting of trees around saline areas, and the drainage of stagnant paddocks. Only a few farmers have been willing to make changes on a larger scale.

Table 8. Percentage of farmers investing in land conservation who observed a benefit

Land conservation practice	Farmers observing benefits (%)
Drainage	51
Fencing	45
Perennial pastures	43
Trees	49
Salt-tolerant species	32

Interestingly, there was a clear disagreement with the proposition that 'landcare doesn't work'. Perhaps this reflects a view that land conservation practices can be effective against some types of land degradation, even if it is less effective against salinity. Alternatively, they may be reflecting a view that the available management practices would work against salinity if they were implemented at an adequate scale.

Reasons for low levels of adoption

One factor contributing to the low adoption appears to be farmer misperceptions. This is likely to be partly a result of the difficulty of accurately observing the extent of salinity (Barr and Cary 1984), or the impacts of any treatment (Pannell 2001*a*). Most farmers did not even know whether ground-water levels have risen or fallen on their properties in recent years. This lack of commitment to monitoring their salinity problem probably reflects the failure of most farmers to fully appreciate its seriousness. This represents a serious dilemma for policy makers, since farmers seem unlikely to appreciate the value of monitoring without first beginning to monitor.

Over half of the landholders believe landcare changes to be uneconomic. The absence of quick and easy solutions to dryland salinity was considered a major reason for the lack of change on the ground.

In the absence of 'quick and easy' solutions, economically profitable solutions would seem to be needed. These are available for some, but not all, of the upper catchment in the form of *E. globulus*. One farmer said 'I believe that tree-farming by tree companies is not the answer to salinity problems because they only use the best land.'

Shortage of resources was a problem. Labour time was limited, and financial constraints were preventing further implementation of landcare practices. For example, 1 respondent stated, 'I am 80 years old and am planting trees on a property that has shown a loss for the last 5 years at least'.

There was a perceived improvement to the general health of the farming environment with land conservation activities, but specific improvements (e.g. in yields) attributed to landcare were only recognised in a minority of

Table 9. Farmer perceptions of land quality indicator changes on their properties (% of respondents)

Land quality indicator	Increased	No change	Decreased	Don't know
Groundwater level	20[A]	12	9	59
Soil erosion	12	68	11	9
Crop yield	23	62	3	11
Stocking rate	13	67	16	5

[A]An increased ground water level represents a decreased depth to the watertable.

cases. It is not surpising that farmers have negative opinions about the economic returns from these landcare activities.

The extent to which each farmer is able to alleviate salinity problems will depend on where the property is located in the landscape. For valley farmland in catchment discharge zones, the ability to prevent salinity is severely limited by the difficulty of persuading neighbours to invest in land conservation measures for which they will not be the main beneficiaries. The only viable management options for such valley farmers may be to plant salt-tolerant species over the affected areas, or simply accept that the land will becomes saline.

Some implications for policy

Despite the high level of farmer attendance at landcare events, and high awareness of dryland salinity problems, it appears that adoption of preventative practices is at a scale that will not prevent continuing increases in the area of saline land in the Upper Kent River catchment [consistent with Barr *et al.* (2000) and Curtis *et al.* (2000) in the Murray–Darling Basin]. Clearly, the past reliance on persuasion, peer pressure, extension and research has been unsuccessful in achieving sufficient change. Whatever policy measures are taken in future, it is clear that they must do much more than past measures to change the incentives of farmers to adopt new practices at a great enough scale.

The use of perennial pasture is not very popular with Kent farmers; only 1 farmer had planted lucerne. If perennial pastures were necessary within an agricultural landscape system to prevent recharge there would be a need for more appropriate local species and incentives for farmers to adopt them.

Few farmers are working with their neighbours to collectively address salinity problems. Although most perceive salinity as a catchment issue, they continue to manage it independently on their own farms. If it is not possible to identify perennial plant options that are commercially profitable to the farmer who plants them, it may be necessary for the government to explore means of facilitating financial flows between farmers who share a hydrological system.

If salinity in the Upper Kent River catchment was to be substantially controlled, the broader non-agricultural community would be a major beneficary, especially due to the return of the Kent River to a potable water supply. As noted earlier, state government agency, The Water and Rivers Commission, is subsidising farmer implementation of salinity prevention measures in a small number of catchments (including the Kent) at a rate of A$2.5 million per year (Anon. 1996). It would seem to be important to determine (i) whether these subsidies are effective, efficient and equitable, (ii) whether the magnitude of the subsidy is sufficient to encourage sufficient change, (iii) if not, how might the funds be employed to achieve maximum leverage over farmers' farming practices, and (iv) how should the subsidies best be complemented with other incentive-based or regulatory systems.

Finally, the lack of similar surveys to this in Western Australia is most striking. Rigorous evaluation of the major government programs addressing salinity would require information of this type, and yet in almost all areas, the

Table 10. Landholder opinions on why dryland salinity is still a major environmental problem

Dryland salinity is still a major environmental problem because …	Agree	Don't know	Disagree
It is too big to fix	42	10	48
No quick and easy solutions exist	83	2	16
Landcare doesn't work	6	18	76
There is no spare time available for landcare	54	6	40
There is too much future uncertainty	48	11	41
There is no spare land available	31	22	47
Government drainage restrictions exist	50	29	21
There is no catchment management plan	27	20	53
It is too uneconomic to fix	52	8	39

information has not been collected. We suggest that replication of this study in other regions would benefit the policy decision-making process.

Other policy issues could be raised in the wake of these results. In the issue of brevity, we refer the reader to the following papers which focus specifically on salinity policy, and include deeper coverage of policy issues arising from this study: Kington and Smettem (2001), and Pannell (2001*b*, 2001*c*).

Conclusion

Farmers in the Upper Kent River catchment of Western Australia face a substantial challenge in preventing or dealing with the ongoing worsening of dryland salinity on their farms. On the other hand, they are favoured relative to other Western Australian farmers facing similar salinity threats by virtue of the availability of a perennial plant species that can be commercially profitable on suitable soil types, and by the availability of state government subsidies to help protect the Kent River from salinisation. Nevertheless, it appears that at the time of the survey, the level of implementation of salinity prevention treatments was still well below that necessary to prevent further salinisation. Of course, a cross-sectional survey of this type provides only a snapshot, and the situation in the Upper Kent has continued to evolve since the survey was undertaken.

A variety of possible reasons for the low level of adoption of treatments have been identified, and supported by evidence from the survey. The reasons include a tendency for farmers to under-rate the seriousness of salinity and to over-rate the effectiveness of treatments they have implemented (or might implement in future). Other reasons include, the complexity, difficulty and expense of available treatments (which are distinct from their effectiveness against salinity), limited resources available to invest in the treatments, flows of salinity across farm boundaries, and the absence of economically profitable treatments for all soil types.

The results of this study indicate that the existing policy approach of providing encouragement, information and persuasion to farmers and relying mainly on their voluntary action is not succeeding. This reinforces arguments to this effect which are increasingly being made in the policy arena (e.g. Barr 1999; Frost *et al.* 2001; Pannell 2001*b*).

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