



Catchment Response to Farm Scale Land Use Change: The Journey

HP Cresswell, IH Hume, D Race, M Glover, E Wang, TL Nordblom and JD Finlayson

February 2009



Grains Research &
Development Corporation



Industry &
Investment



Copyright and Disclaimer

© 2009 The State of New South Wales, the Commonwealth of Australia, the Commonwealth Scientific and Industrial Research Organisation, and Charles Sturt University (“Copyright Holders”). To the extent permitted by law, all rights are reserved and no part of this publication covered by copyright may be reproduced or copied in any form or by any means except with the written permission of the Copyright Holders.

Important Disclaimer:

The Copyright Holders advise that the information contained in this publication comprises general statements based on scientific research. The reader is advised and needs to be aware that such information may be incomplete or unable to be used in any specific situation. No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice. To the extent permitted by law, the Copyright Holders (including their employees and consultants) exclude all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.

Publication data:

Cresswell HP¹, Hume IH², Race D³, Glover M¹, Wang E¹, Nordblom TL², and Finlayson JD² (2009). Catchment Response to Farm Scale Land Use Change: The Journey. CSIRO, NSW Department of Industry and Investment, and Charles Sturt University.

¹CSIRO Land and Water

²NSW Department of Industry & Investment

³Charles Sturt University

Cover Photograph:

Photographer: Hamish Cresswell
© 2009 CSIRO

CONTENTS

1. Introduction	1
1.1. Why document the project 'Journey'?.....	1
1.2. Previous research and engagement with landholders in Simmons Creek	3
1.3. Existing communication networks.....	3
2. Initial engagement with the catchment community and project commencement	3
2.1. Initial meetings with Alma-Park Landcare	3
2.2. The commencement phase	4
3. The farmer members of the project team.....	4
3.1. How the farmers were recruited and their contribution.....	4
3.2. Feedback on land use modelling: An effective way to engage?	5
3.3. The landholder perspective	5
4. Sharing experiences with Wallatin Wildlife and Landcare Inc. (WA).....	7
4.1. Visit to the Wallatin-O'Brien catchments.....	7
4.2. Wallatin Wildlife and Landcare Inc. visit to Simmons Creek.....	8
5. Engaging the wider catchment community	9
5.1. The off-site nature of salinity in Simmons Creek	9
5.2. Cost of implementation as an impediment to adoption.....	9
5.3. Community capacity to change.....	9
5.4. Linking Natural Resource Management (NRM) programs with agribusiness sector R&D	11
6. Communication	11
7. A proposed approach to engage communities in salinity mitigation	13
8. How to efficiently analyse salinity mitigation in other catchments.....	14
8.1. What approach is recommended for use elsewhere?	14
8.2. What are the essential prerequisite data?	16
9. Summary	17
Acknowledgements	18
References	18

Catchment Response to Farm Scale Land-Use Change: The Journey

HP Cresswell¹, IH Hume², D Race³, M Glover¹, E Wang¹, TL Nordblom²,
and JI Finlayson²

¹CSIRO Land and Water

²NSW Department of Industry and Investment

³Charles Sturt University

1. INTRODUCTION

1.1. Why document the project ‘Journey’?

The effectiveness of applied agricultural research can be enhanced by researchers and landholders engaging in a co-learning approach, where each other’s expertise is recognised and there is active two-way learning. Effective landholder participation keeps the research focussed on practical, implementable solutions to real problems or opportunities. The landholders engaged in the process gain a better understanding of the research, and learn how to evaluate and apply the results. They are able to influence the research and gain more ownership of the research process.

In participative research, learnings come from evaluating and recognising mistakes made and also recognising what elements of an approach were successful. Generating and sharing a written history of our approach to participative research and the mistakes and successes in this project will enable people not directly involved in the project to learn from the experience. That is the intent of documenting the project ‘Journey’ from this ‘Catchment Response to Farm Scale Land Use Change’ (Simmons Creek) research project. The project ran from January 2005 to February 2009¹ with the following objectives:

1. In the Simmons Creek focus catchment (see Figure 1)
 - a. Assess the location and degree of change in the surface water balance needed to meet catchment management goals.
 - b. Quantify the water balance and productivity of the range of locally relevant agronomic options.
 - c. Use a participatory approach, biophysical modelling and economic analysis to explore the balance between property-scale objectives and catchment targets.
2. To develop a generic process to support decisions in other grain growing areas
 - a. Evaluate the process followed in the Simmons Creek case study including data requirements and alternative models and analysis tools.
 - b. Identify key economic and physical data required to support the decision processes and match those needs with data readily available in other areas.
 - c. Document the process to be followed in other areas.

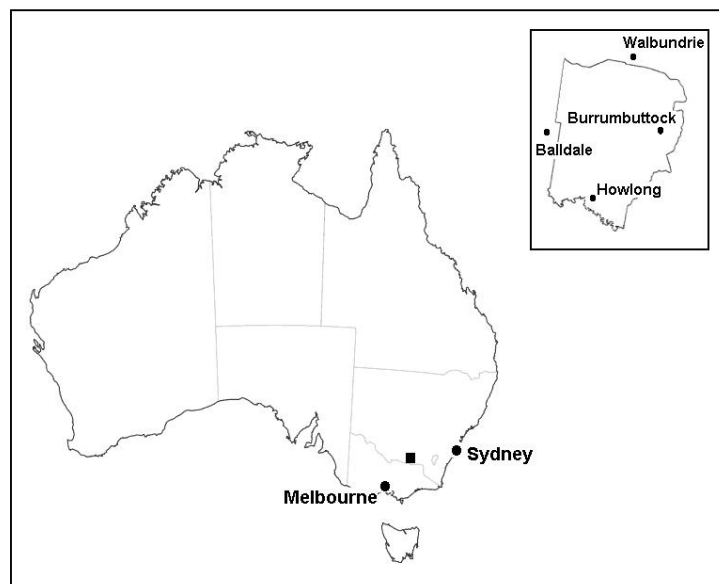
¹ A detailed description of the methods, results and conclusions from the ‘Catchment Response to Farm Scale Land-Use Change’ project are presented in Cresswell et al (2009). This description of the project journey is designed to be read in conjunction with the detailed technical report.

The case study approach included evaluation of the cost of achieving natural resource targets considering the expected lower on-farm income, at least in the short term, earned by more 'environmentally friendly' land uses. It is hoped that this research will contribute towards growers making well informed selections from a suite of practical agronomic and other land uses to achieve 'least cost' attainment of catchment environmental targets. Such management decisions being based on sound knowledge of (a) the impacts on catchment groundwater, salt mobilisation and discharge to Billabong Creek, and (b) the on-farm economic benefits and costs associated with changes from current practice.

The initial research providers were CSIRO Land and Water, NSW Department and Primary Industries (NSW DPI) and NSW Department of Infrastructure, Planning and Natural Resources (DIPNR; currently Department of Environment and Climate Change). NSW DIPNR withdrew from the project in 2007 after having been unable to commit the contracted resources. Charles Sturt University was subcontracted to the project by NSW DPI in 2006 to provide rural social research. All of the research providers had difficulties at different times during the project with providing continuity of staffing.

The Grains Research and Development Corporation (GRDC) provided the core funding for the project and the research providers co-invested. CSIRO Land and Water entered into a contract with GRDC for project delivery, NSW DPI and NSW DLWC subcontracted to CSIRO, and Charles Sturt University subcontracted to NSW DPI. Simmons Creek landholders and other contributors gave their time without fee to the project (refer to the acknowledgements).

Figure 1. Location of the West Hume area of southern NSW



Simmons Creek was initially selected as an area of interest for dryland salinity mitigation after Williamson et al. (1997) identified Billabong Creek at Walbundrie as having one of the highest rates of increase in stream electrical conductivity within the Murray-Darling Basin. Subsequent investigations identified saline groundwater inflows in reaches upstream of Walbundrie. There was anecdotal evidence of salinity contributions from Simmons Creek catchment and so the hydrogeology of the catchment was investigated by English et al. (2002) and stream flow and monitoring equipment was installed. The exact quantity of salt exported from Simmons Creek is unknown although during the current drought salt export

appears to have fallen to low levels. Simmons Creek catchment at around 17,000 ha is not a large contributor of salt in the context of the Murray-Darling Basin; however, it does represent both a risk and opportunity for prevention of future salt export, given the salinity of the groundwater in close proximity to Billabong Creek.

1.2. Previous research and engagement with landholders in Simmons Creek

The Simmons Creek catchment was a focus area for research within the ‘Heartlands Initiative’ (2000–2003), a program which combined research with the implementation of on-ground environmental works such as establishment of perennial pastures and trees. Landholders within the Simmons Creek catchment were engaged in Heartlands and extensive programs of soil survey, salinity investigation, and groundwater and stream monitoring. These involved direct interaction with landholders. Thus, at commencement of this GRDC funded project there were some established relationships between CSIRO researchers and the Simmons Creek landholders to build from and there was a positive legacy from Heartlands.

1.3. Existing communication networks

Heartlands had engaged with Simmons Creek landholders through the Alma Park/Pleasant Hills Landcare group. The group has been active and in 2001 published a catchment plan (Alma Park Pleasant Hills Landcare Inc., 2001). The current project aims to utilise existing communication networks and commenced by working through the Landcare group and the NSW DPI district agronomist who had a good communication network amongst growers in the area. There were also a number of other networks within the area mainly linked with agribusiness: the sales agronomists of rural merchants and farm consultants, and a ‘Farm 500’ financial planning and analysis group.

2. INITIAL ENGAGEMENT WITH THE CATCHMENT COMMUNITY AND PROJECT COMMENCEMENT

2.1. Initial meetings with Alma-Park Landcare

CSIRO participants met with representatives of Alma Park/Pleasant Hills Landcare and the district agronomist in April 2004 to seek their input into the research proposal prior to its submission to GRDC. This first meeting sought input from the landholders at the meeting on researchable issues of interest to them, on a draft research proposal, on an equitable process of forming a landholder focus group and on the best ways to communicate with people in the Simmons Creek catchment. The outcomes of this first meeting were to (1) propose to a full meeting of Alma Park/Pleasant Hills Landcare that the group participates in the new project and (2) suggest that an expression of interest process should be followed to ensure that selection of focus group participants was viewed as open and fair. Subsequently, CSIRO distributed hard copies of different Heartlands communication outputs to participants, placed an article about the proposed project in the Landcare group’s newsletter, and designed a process for forming the focus group.

The research proposal was subsequently finalised and submitted GRDC. GRDC requested that CSIRO link and merge the proposal with those submitted by NSW DPI and NSW DIPNR and so a new collaborative research proposal was developed. Alma Park/Pleasant Hills Landcare did not have direct involvement in the reconfiguration of the research proposal—probably a missed opportunity for farmer input into the project specification.

The revised project proposal was approved by GRDC and commenced January 2005.

2.2. The commencement phase

The commencement phase of the project included the following activities:

- a facilitated meeting of the research providers to design and develop a shared set of objectives and operating principles
- clarifying methods and developing a work plan
- data sharing between research providers

The project research team undertook a tour of the Simmons Creek catchment to be fully briefed on previous research and to consolidate the project's approach and work plan by:

- getting to know each other better and developing a team approach
- looking at the landscape, and discussing our current understanding of how it functions
- discussing what management options the landholders have
- discussing current modelling and the need to link the economic and biophysical processes.

The team of researchers met with Hamish and Ian Ellis, who are landholders in the catchment, and discussed their management practices in detail. This was extremely valuable and Hamish Ellis subsequently continued to contribute to the project as a member of the focus group.

3. THE FARMER MEMBERS OF THE PROJECT TEAM

3.1. How the farmers were recruited and their contribution

After further planning the project leaders wrote an introductory letter and prepared a map that was sent out to all landholders in the study catchment. It included an invitation for people to express interest in participating in the project landholder focus group. The researchers specified the proposed role of the landholder focus group as follows:

- provide advice on land use options
- provide advice on our catchment, agronomic, and economic analysis (scenarios, data input, verification, discussion of output)
- contribute to communication/engagement—locally, with the wider catchment community, and others (ideally able to champion the project assuming the project merits it)
- provide advice on development of products aimed at other landholders (usefulness, useability etc.)
- provide general input to project direction and approach.

The project needed to collect various data to help understand current agricultural practice in the Simmons Creek catchment and farmer views on changes in land use. A short survey, ‘Socio-economic dimensions of farming in the Simmons Creek catchment’, was designed for landholders to complete either face-to-face or by telephone with the NSW DPI district agronomist and a local catchment coordinator, both known and trusted in the area. The contact with landholders also gave the opportunity to clarify the project’s purpose and intended outcomes, and to assess the interest of landholders in participating in the project focus group. Through this process four landholders were identified to form the focus group: Bernie Coyle, Hamish Ellis, Leon Kohlhagen and Peter Wallace.

All four landholders contributed throughout the life of the project. Their knowledge, commitment and insight were highly valued by the rest of the project team.

3.2. Feedback on land use modelling: An effective way to engage?

The project required a sound understanding of the land use and land management practices in Simmons Creek catchment including the spatial distribution of land use (land use mapping). There was a need to develop typical land use scenarios with, for example, well-specified crop rotations, pasture phases and fertiliser application strategies. In addition, gross margins were developed for the different land use options requiring detailed description of typical farm management and field operations. Detailed paddock data was required for the verification of model predictions. Seeking input on all of these was an effective way to engage the focus group—the project required and valued this knowledge and subsequently the landholders enjoyed contributing their expertise. We often combined working meetings with an evening meal to allow opportunity for building relationships, to ‘give something back’ to the farmer contributors and to fit in with the farming day. Providing updates on progress helped keep the focus group engaged and, as the project continued, the focus group became more involved in evaluating and discussing project results.

In March 2007 some of the project team visited our ‘sister’ GRDC project team (GRDC WWL0001 ‘Bringing it all together’) in the Wallatin and O’Brien catchments near Kellerberrin in Western Australia. There had been ongoing but infrequent contact between the two projects in order to share approaches and lessons in relation to salinity management in strongly contrasting landscapes. All four landholder members of our project team travelled to WA and contributed strongly to meeting the objectives of the visit (see below) including a detailed explanation of the Simmons Creek project and local farming systems to landholders and researchers from WA. Three days of working closely together as a project team and being stimulated by what we were shown in Wallatin/O’Brien was highly beneficial in team building and further strengthening the degree to which the landholders were embedded in the research team.

3.3. The landholder perspective

The project’s focus group farmers were interviewed as part of ongoing evaluation to assess the project’s effectiveness at achieving a level of co-learning. This assessment also explored the extent to which the model developed by the project was effective in supporting farmer decision making in the Simmons Creek area. The following reflects the focus group perspectives.

Engaging with landholders

The project's research identified where land use could be changed to reduce saline discharge from Simmons Creek at least cost. The most cost-effective way to manage small decreases in the salt load was if farmland was assessed as under 'low input' management and then converted to 'high input' management (e.g. establishing crop rotations incorporating lucerne). However, much of the 'low input' farmland is farmed under entrenched financial and social constraints preventing the conversion to a 'high input' system. Examples are farm businesses without the financial reserves to absorb establishment costs, and landholders wishing to reduce the workload (i.e. 'down-shift' farming)—factors that are incongruous with 'high input' farming systems. Given dryland salinity is not currently viewed locally as a critical issue, and without the strong desire or capacity to change from low input to high input farming, it remains a considerable challenge for the project to effectively communicate and engage with the wider population of farmers within the Simmons Creek area. This is illustrated by a farmer's comment: '... you won't get the landholders who need to change (i.e. 'low input' farmers) to a meeting ... you need to let them come to the project'.

Communication with farmers about the project was also challenged by having no on-ground activity (e.g. research or demonstration site) to engage the wider farming community. Some of the farmers' comments that illustrate this point include:

- '... having something on-ground may have attracted more interest in the project from my neighbours'
- '... the project needs to have some 'carrots for change'
- '... a field day with local agronomists ... for farmers and agronomists might work'.

Benefits for 'focus group' farmers

All of the 'focus group' farmers reported benefits from being involved in the project. These benefits were expressed as:

- '... I've got a far greater understanding of the hydrology and how the whole system works ... the underground drainage ... we never really understood this before'
- '... I now know there's not one simple answer, there're different answers for different parts of the catchment'
- '... the exchange visit was stimulating, even though what they're doing (in the Wallatin project) doesn't directly translate to us ... helped to get us thinking outside the square ... seeing different approaches' (see below for explanation of the interaction with Wallatin Wildlife and Landcare Inc. (WA)).

The level and nature of involvement in the project was appropriate and was supported by the 'focus group' farmers, in some of their comments:

- '... it wasn't too onerous ... I enjoyed our meetings and learning about the different research going on'
- '... I was a bit cynical at the start about the need for more research about salinity, but I've gained a lot of knowledge about our watertable and how easy it could be to control it'.

Refining the project's approach

Some farmers expressed the need for the project's scientists to better explain their assumptions, data, calculations and analysis in 'layman's terms'. Building a common 'language' so that both the members of the project team and the project's target audience

can participate equally in the same ‘conversation’ is an important element of effective co-learning—learning that bridges disciplines and roles.

Several farmers expressed some concern that the project, as it stands now, does not appear to be linked to any tangible or on-ground action. This was expressed by one farmer: ‘... the project needs to be linked to something physical at the end ... like more funding for perennial pastures’.

This view was supported by another farmer, who reported the project: ‘... was good, but it was too slow to get some action ... it lost some momentum, with staff changes ... it probably should have had some concrete milestones for on-ground action at the end’.

The current project was primarily a desk-top study with the exceptions of data collection for model parameterisation and social analysis of ‘capacity to change’. It did however involve ongoing monitoring of weather and groundwater. The above farmer comments are perceptive and point towards the previous construct of Heartlands, where funds were available to support on ground works within the same program that funded research to help target those works.

The project’s focus group farmers provided considerable benefit for the wider project team by:

- providing local and actual agronomic data as input to the project’s model
- challenging and verifying the model’s calculations and results
- adding a local context when analysing the implications of the model’s results
- providing access to the wider farming community within the Simmons Creek area via their personal networks
- providing an insight into how the project might best communicate with local farmers.

4. SHARING EXPERIENCES WITH WALLATIN WILDLIFE AND LANDCARE INC. (WA)

4.1. Visit to the Wallatin-O’Brien catchments

Some of the GRDC Simmons Creek project team visited Kellerberrin, WA on March 26–29, 2007. The purpose of the visit was to:

- gain an understanding of our ‘sister’ GRDC project in Wallatin catchment WA, including assessment of the methods that they have adopted
- be able to make better recommendations about future projects or applications outside of Simmons Creek based on learning’s from the Wallatin catchment project
- contrast the two GRDC projects (issues, drivers, environment and methods) and discuss this in our project reporting
- learn about the nature of salinity in WA and approaches to combat it and farm successfully in saline conditions

- within the Simmons Creek team, further discuss our own project and strengthen our interaction as a project team.

Some observations from the visit follow. In the Wallatin catchment most salinity consequences of farmers' actions were on-site or 'internal', i.e. farmers can benefit from their own actions in combating dryland salinity. This is in contrast to Simmons Creek where most salinity impacts are off-farm; thus, farmer desire and need for action is generally much higher in Wallatin than in Simmons Creek. We saw only one instance of off-farm impact, resulting in a loss of native habitat. The farmer's response in this instance was to do nothing and his view was that the cost of any actions should be borne by those wanting change. This attitude appeared fairly typical in the upper catchment which was fairly immune from salinity; therefore, farmers were not under pressure to take action. Some farmers, driven by the desire to reclaim previously productive land on the valley floor, were installing deep open drains in Wallatin. The drainers seemed to have little concern about the consequences of their actions for either the environment or farmland downstream. So farmers in both catchments are likely consistent in being more concerned about on-farm impacts of salinity and much less concerned with off-site consequence.

The decision support analyses developed in Wallatin are spatially independent and operate at only the scale of the paddock or farm. This spatial independence reflects the nature of salinity in Western Australia, where the impacts are predominantly on-farm (although it could be argued that regional scale economic consequences of salinity interventions should be assessed). The external salinity impact of on-farm action in the eastern states requires the complex integration of the economic and biophysical consequences of action on a sub-catchment or regional scale. Given the bio-physical differences between the two catchments, a different approach to assessing salinity management was appropriate in Simmons Creek.

Rural social research in both catchments has identified that a farmer's capacity and willingness to change is driven by more than just profit maximization. Risk aversion ranks highly in the decision to adopt new practices. A spatially explicit 'change resistance index' would allow these factors to be quantified. All analyses, biophysical, economic and social, must be done spatially so that either the need for change can be matched to those landholders who have the both the capacity and desire to change, or the policies to increase the capacity and desire to change of landholders can be delivered in areas where change is needed.

4.2. Wallatin Wildlife and Landcare Inc. visit to Simmons Creek

A group of farmers and scientists from Wallatin, WA visited the Simmons Creek in mid-2008. The Wallatin group observed how salinity in Simmons Creek catchment is more of a water quality than a land degradation issue and that there are agricultural users of the water downstream. The stream salinity levels in the Simmons Creek area are not 'beyond repair', as is the case with the high salinity water leaving the Wallatin area. This visit by the Wallatin group reaffirmed that most of the key motivating elements for land use change to manage salinity are present in the Wallatin catchment but many are absent in Simmons Creek. The most notable being low ownership of the salinity problem, measured as actual or potential reduction in farm productivity by salinity.

5. ENGAGING THE WIDER CATCHMENT COMMUNITY

5.1. The off-site nature of salinity in Simmons Creek

Most salinity impacts from the Simmons Creek catchment are off-farm and long term. Conversely, there is little ground surface salinity expression and little is predicted in the future. The nature of the hydrology of Simmons Creek is such that movement of saline water directly into Billabong Creek is likely to continue to be the main salinity impact. Farmers are much less concerned with off-site salinity consequences than they would be if impacts were on-farm². This reality, plus the impact of prolonged drought which has lowered water tables thereby reducing salt export and adversely affected farm incomes, results in salinity being a low priority for most farmers in Simmons Creek. Without the drivers of dryland salinity being an obvious (severe), localized (on-farm, compared to downstream) and immediate threat, most landholders have a variety of more immediate agronomic, financial and social issues to address. This presents a major challenge to engage landholders on salinity management with a view to adopting land use strategies to address salinity issues in Simmons Creek. Expecting farmers in Simmons Creek to contribute financially to mitigating an off-site salinity impact appears unrealistic in the current context.

5.2. Cost of implementation as an impediment to adoption

The least cost strategy to reduce salt load in Simmons Creek catchment would have most land use change (both in area and degree) occurring in a small number of subcatchments. Broadly, these changes are to replace cropping rotations with tree plantations in saline catchments and to change to higher water yielding land uses in non-saline catchments. In both cases, these changes result in significant loss of income. Thus, the brunt of the cost of salinity management within the whole catchment is borne by only a few farmers; the rest of the catchment remains unaffected until high levels of salinity mitigation are sought. Farmers are unlikely to undertake this remedial work for philanthropic reasons. However, since our analysis estimates the cost of these land use changes, it could form the basis to negotiate the subsidisation between the interested parties (likely the CMA and downstream beneficiaries). Subsidies could be discounted according to the discrepancy between the current and the potential (i.e. the bio-economically optimal land use unconstrained by social factors) earning capacity of the land; both of which are estimated by our approach.

5.3. Community capacity to change

Variables that help to indicate landholders' capacity and willingness to explore alternate land use options include:

- property size and type of enterprise
- rural land value compared with agronomic value
- level of household income & proportion from off-farm sources
- long-term plans for their property (e.g. reflecting succession planning, farmer age)

² Farmer behaviours are the same in the Wallatin-O'Brien catchments when faced with off-site issues, but the salinity expression in the WA catchments is strongly on-site contrasting with Simmons Creek.

- involvement in producer and/or Natural Resource Management groups.

The findings from interviews conducted with Simmons Creek landholders in late 2006 include the following:

1. The prevailing mood amongst farmers about the future of agriculture in the district varies from 'a quiet optimism' by some (larger productive properties), to 'being pessimistic' by others (smaller less productive properties)— due to the difficult climatic and commercial environment experienced over recent years [implication: farmers pessimistic about their long-term prospects for farming are unlikely to invest greatly in new technologies or land management options].
2. Many farmers want to reduce their workload in the next 3–5 years and improve the 'lifestyle' aspects of their properties (e.g. more time to enjoy their farms, be able to take holidays occasionally), even if it means not maximising farm profitability [implication: many farmers are looking for options that reduce the workload and intensity of farming - that equates to looking for profitable low-input farming systems. Note that this project has identified intensification with higher inputs as being advantageous in reducing salt export from Simmons Creek catchment].
3. Most families are highly dependent on agriculture for household income [implication: any proposed changes in land-use need to be considered in terms of impact on farm incomes (e.g. costs & benefits, risks, period before returns)].
4. An estimated 40% of farmers are intending to transfer the farming business/property to their children within the next 10–15 years [implication: these farmers are likely to be motivated to invest in long-term strategies to enhance the production, capital value and sustainability of their properties].

The results from this project suggest reductions in salt delivery are achievable in Simmons Creek by intensification and then planting trees in selected areas. The high cost of tree planting could be offset at catchment scale by changing other land to higher input cropping systems, more profitable than the low input systems common in the area. The parts of the catchment where land use change potentially offers least-cost environmental benefit are however those where landholder desire for and capacity to change are most limited.

Shifting to higher input production systems means a different risk profile, longer working hours, and long term investment in farming operations - changes that don't fit with current objectives of many farmers in the catchment or with the high degree of pessimism about the long term future of farming. Current land use has an average return of \$143/ha/yr, lower than the \$172/ha/yr modelled as economically optimal. Economic optimisation is achieved by changing from low input to high input rotational farming; but many farmers' associate high input farming with high risk. So land management in Simmons Creek is generally more conservative in approach than what the long term simulations suggest as economically 'optimal'—reflecting personal business risk and lifestyle objectives, impacts of variable costs (e.g. fuel) and market prices, debt levels, and the influence of poor farming conditions in recent years on farmer optimism. Thus, modelling needs to reflect the risk profile of the farming community in some way.

Climate change is becoming a significant factor affecting desire and preparedness to change farming practice for mitigation of dryland salinity. Drought has resulted in lower water tables and less salt export from Simmons Creek in recent years and this project predicts that if future climates are drier, then deep drainage will be reduced implying less water contributing to dryland salinity. The extent to which climate change might 'look after' salinity mitigation in Simmons Creek is uncertain but farmers are much more likely to 'wait and see' rather than to invest in salinity management at this time.

Some farmers have ongoing interests in undertaking revegetation on their farms to enhance biodiversity. One way to lever salinity benefit from this interest in revegetation for biodiversity may be to reward biodiversity plantings in those locations where they also achieve a degree of salinity control (i.e. multiple benefit plantings).

5.4. Linking Natural Resource Management (NRM) programs with agribusiness sector R&D

Research of the nature being undertaken in the Simmons Creek project is much more likely to be embraced by landholders if it were directly linked to programs providing funds to manage salinity. Some farmers expressed some concern that this project: “is not linked to something physical at the end ... like more funding for perennial pastures”; “... (the project) probably should have had ... some on-ground action at the end”. This highlights the need for stronger connection between CMA on-ground works programs (‘the NRM world’) and agricultural sustainability research, and is also a reminder of the value of running local on-farm demonstrations.

Currently there is something of a dichotomy between the institutional structures and processes in NRM, and those associated with production agriculture. This is reflected in the NRM grant processes administered through catchment management authorities, arrangements for R&D funding and the general separation of NRM and production agriculture.

Linking research and development with NRM investment programs was previously achieved through the Heartlands Initiative in Simmons Creek area. The authors recommend that GRDC considers strengthening linkages with programs of NRM investment being conducted by catchment management organisations in grain producing catchments, with a view to supporting development of multipurpose agricultural landscapes. Linkages can be initiated by R&D project teams and local catchment groups as has been achieved to an extent in Wallatin, WA and in the current project. However, constructing programs with both NRM financial incentives and supporting R&D would be more efficient and effective.

6. COMMUNICATION

It has been the wrong time to try to communicate with and engage landholders on salinity management in Simmons Creek. Farmers currently have other more pressing concerns with severe and prolonged drought, increasing input costs, and falling commodity prices. Farmers in Simmons Creek are not prepared to invest in land use change to mitigate off-site salinity impacts in this time of drought and predicted climate change. Nor are farmers operating ‘low input’ land management systems looking to increase risk and intensify their farming operations. Catchment management authorities however continue to manage programs of NRM investment aimed at enhancing biodiversity, mitigating salinity, and addressing soil and water quality. The results of this project are expected to be of benefit in prioritising the spatial allocation of financial revegetation incentives so that water and salt targets can be met at least cost. The provision of information on the costs of meeting often arbitrarily set river salt and water targets will also be helpful in reviewing the practicality and maybe in revision of those targets. At the current time therefore the benefits from this project are most likely to be realised by focussing communication and adoption towards the CMAs. Subsequently this work has been presented to staff of the Murray CMA and to

a wider audience at the Murray CMA Salinity exchange conference (Albury, Feb 19 and 20, 2009) which also included a tour to Simmons Creek catchment.

Various other communication mechanisms have been used as is summarised below:

Written output - aimed at growers and/or catchment managers

Hume IH, Robertson MJ and Price P. (2008). Helping Grain Growers Manage Dryland Salinity. Understanding catchment water balance and salinity management options. Grains Research and Development Corporation Report 08/003.

Hume IH. (2008). Simmons Creek: Farming systems options and catchment salinity response 1. Community engagement, Wagga Wagga Agricultural Institute Update 2008, NSW DPI Wagga Wagga

Hume IH. (2008). Simmons Creek: Farming systems options and catchment salinity response 2. The best land use to manage salt, Wagga Wagga Agricultural Institute Update 2008, NSW DPI Wagga Wagga.

Cresswell HP, Hill P, Hume IH, Wang E, Finlayson J, Hubbard L, Nordblom T, and Glover M. (2009). Spatial multiple criteria analysis and bio-economic modelling to inform catchment salinity management. 'Salinity exchange - Reinvigorating the Conversation', 19 & 20 February 2009, Albury, NSW

Written output - aimed at researchers

Cresswell HP, Hume IH, Wang E, Nordblom TL, Finlayson JD, and Glover M (2009). Catchment Response to Farm Scale Land Use Change. CSIRO Land and Water Science Report 09/09 2009, CSIRO Land and Water and NSW Department of Industry and Investment.

Cresswell HP, Hume IH, Race D, Glover M, Wang E, Nordblom TL, and Finlayson JD (2009). Catchment Response to Farm Scale Land Use Change: The Journey. CSIRO Land and Water Science Report 10/09 2009, CSIRO Land and Water, NSW Department of Industry and Investment, and Charles-Sturt University [this report]

Wang E, Cresswell HP, Yu Q, and Verburg K. (2008). Summer forage cropping as an effective way to control deep drainage under a south-eastern Australia climate - A simulation study. Agriculture, Ecosystems and Environment 125, 127–136. DOI:10.1016/j.agee.2007.12.009.

Robertson MJ, Cresswell HP, Stirzaker R, Dawes W, Hume IH, Nordblom TL, and Wang E. (2007). Role for models in decision making for complex natural resource problems - the case of dryland salinity in Australia. Proceedings of Farming Systems Design 2007 - An International Symposium on Methodologies for Integrated Analysis of Farm Production Systems, 10-12 Sept, 2007, Catania, Sicily, Italy, <<http://www.iemss.org/farmsys07/>>.

Nordblom TL, Hume IH, Cresswell HP, Glover M, Hean R, Finlayson JD, and Wang E. (2007). Minimising costs of environmental service provision: water-yield, salt-load and biodiversity targets with new tree planting in Simmons Creek Catchment, NSW, a dryland farming/grazing area. AARES 2007, Queenstown, New Zealand. <<http://ageconsearch.umn.edu/handle/10357>>

Wang E and Wang J. (2007). Modelling the performance of different wheat varieties under changed climate: Towards better adaptation. The 4th International Symposium on Intelligent Information technology in Agriculture, Beijing, China 2007.

Wang E, Cresswell HP, and Glover M. (2006). Assessing the Impact of Spatial Variability of Soil and Vegetation on Catchment Water Balance - A Case Study in Simmons Creek Catchment. 18th World Congress of Soil Science, July 9-15, 2006 - Philadelphia, Pennsylvania, USA. (poster paper) <<http://a-c-s.confex.com/crops/wc2006/techprogram/P17809.HTM>>

Presentations to growers, NRM groups and others

Updates to Simmons Creek landholder focus group (including April/06 Feb/07, March/07, June/07, Mar/08, Feb/09)

Culcairn Landcare Inc., 'Salinity Under The Microscope - The Simmons Creek Project', 31st March 2008 Culcairn Council Chambers.

Culcairn Landcare Inc., 'Salinity in the Culcairn Catchment Bus Tour, 16th June 2008.

Murray Catchment Authority Forum, 'The latest techniques to manage catchments', Albury, November 2007.

Murray Catchment Management Authority 'Salinity exchange - Reinvigorating the Conversation' Conference, Albury, February 19-20, 2009.

Simmons Creek catchment field trip. Murray Catchment Management Authority 'Salinity exchange - Reinvigorating the Conversation' Conference, Albury, February 19-20, 2009.

NSW DPI Salinity and Hydrology Program, Planning Meeting Tamworth, March 2008

Presentations to growers from the Wallatin-O'Brien catchments in WA (March 2007).

Presentations and field tour to growers from the Wallatin-O'Brien catchments in WA (June 2008)

7. A PROPOSED APPROACH TO ENGAGE COMMUNITIES IN SALINITY MITIGATION

The following are thought to be key components in an approach to successfully engage communities in salinity mitigation:

- a clear and compelling problem or opportunity defined from the outset
- development of a sound conceptual understanding of the soils and hydrogeology of a given catchment through a field sampling program that (inevitably) has contact with many local landholders and includes communicating the knowledge gained back to the local communities
- programs of groundwater (water level and salinity) and stream monitoring (flow volume and salinity) that involve landholders and include making the data available to landholders on a regular basis
- communication to landholders of evidence on the off-site impacts of salt exported from the catchment

- a research assessment of current land use and alternative land use options for salinity management - the assessment must include land use scenarios with considerable agronomic detail and that are feasible. Preferably local landholders have input into the specification of land use scenarios
- an economic analysis needs to be completed that gives realistic assessment of the costs of different salinity management options including showing those areas where the best benefit:cost can be achieved. Preferably local landholders have input into the costs, prices and assumptions in the economic analysis
- there needs to be policy mechanisms for encouraging and supporting farmers in those parts of the catchment that require salinity management interventions to do so. This could come from the establishment of NRM programs that support the R&D in the earlier steps (above) as well as providing financial incentives (or some other mechanism) that reflects the 'public good' portion of the implementation cost
- there needs to be public investment helping offset the cost to individual farmers of undertaking salinity mitigation works - this includes providing ongoing advisory support to farmers adopting new land use options, and being prepared to offer financial incentives as more flexible annuities rather than one-off incentive payments, and supporting the necessary on-going monitoring to quantify the environmental return on the on-ground investment
- ideally new, more cost effective, policy options will be developed in the future, maybe based around markets for ecosystem services, that will enable progression away from the current form of NRM cost sharing
- importantly farmers need to see much more continuity in research and NRM programs to have the confidence to participate - the landholders are in for the long haul but they need to see governments and other agencies running much longer term programs. Short term programs don't allow the lead time farmers require and convey a naïve and unrealistic perception of the time and commitment required to achieve environmental goals.

8. HOW TO EFFICIENTLY ANALYSE SALINITY MITIGATION IN OTHER CATCHMENTS

8.1. What approach is recommended for use elsewhere?

Here the research approach was to:

- engage a focus group of farmers as part of the project team
- examine the feasibility of summer forage cropping through APSIM simulation and field trials
- identify land use scenarios, parameterise the models, and run simulations of alternative land use options so as to identify least cost ways of meeting catchment water and salt targets
- use farmer paddock records and remotely sensed data in local model result verification
- link APSIM with subcatchment scale linear-program bio-economic modelling
- monitor the local weather and groundwater system (water table levels and EC)
- assess farmers' willingness and capacity to change to alternative land use options
- identify future climate change scenarios and use APSIM simulations to assess likely climate change impacts on the water balance and profitability of high input

cropping systems, and analyse strategies to adapt cropping systems to anticipated future climates.

Having developed and applied this methodology in Simmons Creek catchment (refer to Cresswell et al 2009 for details) we now reflect on that experience and consider what approach we might use to provide a similar analysis in another catchment in the future³.

Here we used APSIM simulation to provide estimates of evapotranspiration, runoff deep drainage, crop yield and pasture biomass for specific land use on particular soils, and for given climatic periods. Such information is necessary but requires specialist input to parameterise and run farming system models. However, it is crucial to ground these modelled data by first ensuring that the systems are representative of those practiced in the catchment and second validating them with quantitative data measured in the actual catchment being studied. The approach taken here made sure that these check and balances were in place; the farmer focus group grounded the systems and provided quantitative yield data, the modellers were able to reproduce the components of these systems well but agronomic knowledge and system understanding was needed to understand the interaction between these components and ensure accurate modelling of the complete system.

A variant of this mechanistic approach is to generalise response functions or ‘look up’ tables describing the linked water balance and productivity of the various combinations of land use and soil type. These empirical model-generated relationships between rainfall and runoff or rainfall and deep drainage have been generated using APSIM in other locations (e.g. Ringrose-Voase et al. 2003; Wang et al. 2008). Modelled estimates of crop yield and pasture biomass can be tested against farm records, regional production statistics and input from experts such as district agronomists. However, the estimates of the water balance are much harder to verify as local measurements of evaporation are scarce and deep drainage is seldom measured.

An alternative or complement to using APSIM to generate the water balance and productivity of land use and soil type combinations might be semi-structured synthesis of information via small groups of people with relevant domain knowledge. Semi-formal conceptual models (non numerical) of ‘how catchments work’ could be proposed as hypotheses and justified, debated, and modified before being used to develop and document logical planning or management decision pathways. It relies on participants with high levels of ‘landscape literacy’ and the ability to access and understand data from different disciplines. Such a process is qualitative, can’t provide the same rigour as modelling, and is open to strong participant self-interest but it does avoid the ‘back box’ perception, isn’t reliant on specialist modellers and is readily applicable in different areas. If well organised, such a process could contribute significantly to natural resources management— especially if there are in-built learning processes.

Linear programming would seem an appropriate analysis tool for this application but, as with the farming systems modelling, requires specialist domain knowledge to construct and run the model. Moreover, although the optimisation routines are the same, other aspects of the LP models are specific to the catchment being analysed, meaning ‘model building’ is required for each application as well as model parameterisation.

We recommend a step-by-step investigation type approach to catchment salinity mitigation:

1. First it needs to be ascertained whether the catchment in question has a salinity problem of concern and the nature of that problem (local field observation).

³ The following assessment of method and data requirements for extending the analysis to other catchments is also presented in Cresswell et al (2009) - it is thought useful to include it in both reports.

2. If so, then the basic hydrogeology and salinity processes need to be understood and described as a conceptual model. That conceptual model becomes the current working hypothesis around which initial interventions can be planned along with further investigation if necessary.
3. If significant investment in land use change is being contemplated by this stage then spatial multiple criteria analysis (MCA) can be a useful ‘first principles’ analysis with value in land use planning (e.g. Hill et al 2006). MCA is very well suited to a structured synthesis of information from people with relevant domain knowledge within a participative mode of operation. MCA can use modelling input where appropriate. Recognising and building on the domain knowledge of local CMA and agency staff is important, especially in expanding ‘Landscape literacy’.
4. If there is a need for explicit cause-effect understanding and cost and benefit analysis, then the use of APSIM (to produce generalised relationships for a range of soil types and land uses) combined with simple linear programming economic optimisation has merit. This more complex step dictates R&D domain skills, integrated with local agronomic, farming systems expertise and agribusiness knowledge. Such bio-economic analysis is likely to be required only in areas where large salinity investments are likely to occur.

8.2. What are the essential prerequisite data?

To be able to use our approach to assess least cost approaches to meeting catchment salt and water yield targets there has to be knowledge of the following:

- Salinity processes: hydrogeology; groundwater levels, gradients and salt concentrations; mechanisms of salt delivery, and salt loads being delivered into the streams. A sound conceptual model is very important; there is no basis for managing salinity without such knowledge. This usually requires specialist skills which is probably why such basic understanding is still not available for many catchments.
- Surface water hydrology: stream flows, storages (sinks), channelization, flow network characterisation, and nature of interactions with groundwater are all important. Generally this is easier to derive than the groundwater and salinity processes above.
- Climate: historic weather data is essential and fortunately is usually available through the now well organised observation network with access and interpolation via SILO (Jeffery et al., 2001).
- Land use and management: general land use information is available for many agricultural regions (e.g. from the Bureau of Rural Resources) but studies such as this require more detail on crop rotations, type of pasture (native, annual, perennial), grazing management, usage of fertiliser and other inputs, sowing times, and details on other agronomic operations. Local land management practice has to be classified and generalised in studies like this but it is important to accurately represent local practice. Our ‘focus group’ of local landholders contributed strongly to this aspect of the project.
- Soil type and distribution: the locations, areas, and key functional attributes of soils in the study catchment underpin water balance simulation and the suitability for different land use and management options. The amount and quality of soil information is highly variable around Australia but the data that is available is being organised and made easier to access due to the efforts of the Australian

Collaborative Land Evaluation Program (ACLEP). Soil information remains often limiting however.

- Farming operational costs: for calculation of gross margins detailed land management practice information is required (as covered above) together with the costs of undertaking such operations and of inputs such as fertiliser and lime. The costs are readily available and again our ‘focus group’ of local landholders helped contribute and check this information.
- Constraints to land use transition: appropriate constraints need to be specified to prevent inappropriate land use changes being ‘chosen’ by the model, for example, certain soil types might be unsuitable for sowing a cereal crop. An appropriate set of constraints is required - essentially a task of thinking through the constraints and allowable land use transitions - another process that benefits from local farmer knowledge.

Salinity process and soil information are most commonly lacking. Investment in changes in land use or land management to mitigate salinity is risky and is highly likely to be ineffective unless informed by a good understanding of groundwater hydrology, hydrogeology, soil attributes and surface hydrology.

The above list of data is for planning responses to a known salinity problem of sufficient magnitude to cross a ‘threshold of concern’—where the problem is clearly identified and substantiated enough to justify considerable investment in finding a solution. The important precursor is of course the identification and specification of ‘the problem’—whether the problem is of sufficient concern to justify further investigation. In the case of salinity, the basic information required to conceptualise the problem includes:

- measurement of stream EC and flow volumes
- observation of area and severity of surface salt outbreaks
- observation of groundwater height trends and groundwater EC
- assessment of assets at risk from salinity and the value of those assets
- longitudinal stream surveys if required to identify the stream reaches responsible for significant amounts of incoming salt.

Investment in data and understanding salinity processes beyond the problem definition phase should only occur once it becomes critical to managing the problem. There is some risk that heavy reliance on modelling makes large data demands from the outset whereas other approaches are more commensurate with gradually increasing data collection as required to solve the problem in the most efficient way.

9. SUMMARY

As a consequence of this project we now have a much better understanding of where we might prioritise land use change in the Simmons Creek catchment, what land use change options might be most cost-effective, and the overall costs of interventions for salinity management. There is, however, still doubt about the extent to which salinity mitigation actions are necessary or appropriate in Simmons Creek catchment. Stream and groundwater monitoring has been in place to help address this issue, but it is difficult to distinguish between salt export in the current drought and the likely longer term loads. Salt loads from Simmons Creek should continue to be monitored to determine if or when they exceed a ‘threshold of concern’.

The project greatly benefitted from a small focus group of local farmers being embedded within the research team. They provided local knowledge and agronomic data that, with interpretation by farming systems agronomists, allowed the development of representative, robust models of agricultural production and agricultural hydrology. However, effective communication with the wider Simmons Creek farming community about salinity was difficult because (a) the salinity impacts are off-site, (b) changing to either more intensive farming or growing trees were not considered attractive in a major drought, (c) the salinity threat appears less under future climates and (d) there was no direct access to funds for on-ground works. The main impediments to on-ground action to mitigate salinity include cost, unwillingness to take on additional business risk, and lifestyle objectives that conflict with increased risk or intensifying farming systems.

The assessment of dryland salinity risk invariably requires investment in local data collection, and where salinity is of concern the design of management interventions requires sound local understanding of hydrogeological process, and ideally, comprehensive spatial analysis of alternative land use options including the economic dimension. The risks of progressing with NRM investment aimed at salinity management without good knowledge are high, but these risks are reduced by each step in the proposed approaches to understand salinity as outlined above (starting with basic data collection, problem definition, and then hydrogeological conceptualisation). Each catchment is different and in those where significant salinity problems that exceed a 'threshold of concern' exist (i.e. it's worth investing in finding a solution), there doesn't appear to be any shortcut to avoid the necessary sound basic investment in field data collection and analysis of alternative land use options.

ACKNOWLEDGEMENTS

We extend a special thank you to our project focus group members - Bernie Coyle, Hamish Ellis, Leon Kohlhagen, and Peter Wallace. Thanks also to: the landholders of the Simmons Creek catchment, Lisa Castleman and Dale Stringer of the Murray Catchment Management Authority, and Wallatin Wildlife and Landcare Inc. This project was funded by the Grains Research and Development Corporation with co-investment from CSIRO and NSW Department of Industry and Investment.

REFERENCES

Alma Park Pleasant Hills Landcare Inc. (2001). Alma Park/Pleasant Hills Landcare Group Catchment Plan, March 2001.

Cresswell HP, Hume IH, Wang E, Nordblom TL, Finlayson JD, and Glover M. (2009). Catchment Response to Farm Scale Land-Use Change. CSIRO Land and Water Science Report 09/09 2009 CSIRO Land and Water and NSW Department of Industry and Investment.

English P, Richardson P, and Stauffacher M. (2002). Groundwater and Salinity Processes in Simmons Creek sub-catchment, Billabong Creek, NSW. CSIRO Land and Water Technical Report 24/02, CSIRO, Canberra.

Hill P, Cresswell HP, and Hubbard L. (2006). Spatial prioritisation of NRM investment in the West Hume area (Murray CMA region). Technical Report, CSIRO Water for a Healthy

Country National Research Flagship, Canberra.

<<http://www.clw.csiro.au/publications/science/2006/wfhc-MurrayCMAWestHume.pdf>>

Jeffrey SJ, Carter JO, Moodie KB, and Beswick AR. (2001). Using spatial interpolation to construct a comprehensive archive of Australian climate data. *Environmental Modelling and Software with Environment Data News* 16[4], 309-330.

Ringrose-Voase AJ, Young RR, Paydar Z, Huth NI, Bernardi AL, Cresswell HP, Keating BA, Scott JF, Stauffacher M, Banks RG, Holland JF, Johnston RM, Green TW, Gregory LJ, Daniells I, Farquarson R, Drinkwater RJ, Heidenreich S, and Donaldson S. (2003). *Deep Drainage under Different Land Uses in the Liverpool Plains Catchment. Report 3, Agriculture Resource Management Report Series.* NSW Agriculture.

Wang E, Miles M, Schultz T, Cook P, Maschmedt D, Munday T, Leaney F, Walker G, and Barnett S. (2008). Prioritising dryland areas in the Mallee for revegetation to control groundwater recharge and salt load to the Murray River using a rapid assessment tool SIMPACT. *Australian Journal of Earth Sciences* (in press).

Williamson D R, Gates GWB, Robinson G, Linke G K, Seker M P, and Evans WR. (1997). *Salt trends: historic trend in salt concentration and saltload of stream flow in the Murray–Darling Drainage Division. Dryland Technical Report No. 1, 64 pp.* (Murray–Darling Basin Commission: Canberra.)



Contact Us

Phone: 1300 363 400

+61 3 9545 2176

Email: enquiries@csiro.au

Web: www.csiro.au

Your CSIRO

Australia is founding its future on science and innovation. Its national science agency, CSIRO, is a powerhouse of ideas, technologies and skills for building prosperity, growth, health and sustainability. It serves governments, industries, business and communities across the nation.