Bringing us together: presentations from the Natural Resource Management Division meeting, May 2008

Georgina Wilson

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Bringing us together

presentations from the
Natural Resource Management Division Meeting
May 2008
Summary

In May 2008 a meeting of staff within the Natural Resource Management Division was held in Fremantle to provide an opportunity to hear about expected future directions from senior management, opportunities for networking at all levels and for a small taste of recent research and extension work within the cohort.

Twenty-four topics were selected for oral presentations in concurrent sessions, and the papers from those presentations comprise most of this report. They are listed in the order provided in the program. They range widely across the natural resource management spectrum within the Department of Agriculture and Food.

Results from many projects would have been extended since presentation of those papers and more current details could be obtained from the authors.

Managerial summaries, mostly presented via PowerPoint, have not been included. These presentations were from a more strategic level, as opposed to technical research and extension information.

The overall conclusion at the end of the day and a half was that the exercise had been very useful and should be repeated within the next few years to maintain linkages between staff working in widely separated locations but with many common interests.
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Rangeland assessment

The agroforestry challenge: dollars and the environment

Assisting farmers adapting to salinity - integrating engineering and agronomy in the South West

Bioengineering actions of native plants on soil profiles in semi-arid ecosystems of the South West Botanical Province

Merging biodiversity and production in the Southern Rangelands - Ecologically Sustainable Rangelands Management (ESRM)

Resource condition monitoring and analysis of long-term groundwater trends

Supporting adoption of perennial pastures in the south west low to medium rainfall zone

Planning for impact in catchments: Beyond incentives to technology development

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Groundwater responds by declining in a drier climate in the Northern Agricultural Region

Determinination of the ability of pastures to reduce nitrate-N leaching

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Acidic groundwater in the South West of Western Australia: Its distribution, causes and implications for agriculture

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Climate change – DAFWA policy and research activities

Waterwise on the Farm in Western Australia

The Greener Pastures project - a good model for effective NRM integration with industry?

Modelling reliable runoff from farm scale catchments

* Papers marked with an asterisk are only provided as an abstract; the full versions were not supplied by authors.
Introduction

The Natural Resource Management Division of the Department of Agriculture and Food comprises around 150 staff, located from Kununurra in the north of the State to Esperance in the south-east. Getting together as a group had not happened since the 1990s, and staff feedback during a review of communications within the Division saw an all-of-Division get together as an important activity.

Rebecca Heath from the Extension and Communication project (REX) was nominated to coordinate the delivery of a Divisional Meeting. A working group was formed which included representatives of each region and part of the Division.

To assist with preparations, working group members were assigned portfolios for which they were responsible. The portfolios included Venue, Program, Communications and Registrations, Evaluation, Senior Management Liaison and overall Coordination.

The theme of the meeting – Bringing Us Together – who we are, what we are doing, where we are going – was established based on feedback from staff. This feedback identified the need for the Division to come together in order to strengthen the connections and to find out what everyone was doing and what lies ahead.

The final result was a two-day meeting at the Esplanade Hotel in Fremantle, beginning on Tuesday 13 May and concluding by mid-afternoon on Wednesday 14 May. The event program was devised in consultation with staff and included plenary and concurrent presentations, and a feedback session where staff could discuss and present their views on the Divisions strategic direction. The plenary sessions had a focus on the ‘bigger picture’ including presentations that outlined the importance of agriculture to Western Australia, the role of the department in agriculture and natural resource management, overviews of the Division’s branches and regions and emerging policy issues and directions for the natural resource management sector.

NRM Division Staff were invited to submit abstracts for 24 presentation slots across four concurrent sessions. A committee comprising Hayley Turner, Jamie Bowyer, Rebecca Heath and Janette Hill-Tonkin was established to review the abstracts submitted and select 24 for presentation. Papers for these are included in this report. Additional presenters were invited to submit posters summarising their work which were displayed in the foyer during the meeting.

A facilitated group discussion feedback session on the Wednesday afternoon enabled staff to provide input to the current and emerging direction of the NRM Division, and identified how the Division could do better for natural resource management. The results were compiled into themes and passed to senior management. A response to each theme was formulated, including new activities to address the issues raised.

A high proportion of regional staff stayed at the Esplanade in shared rooms. A casual dinner (barbecue forced inside by inclement weather) on the Tuesday night provided a good opportunity for networking.

Feedback from an evaluation conducted at the conclusion of the meeting and from other sources highlighted the success of the meeting. Many staff considered the meeting as valuable, and indicated that the information learnt and networks made would be of use in their day-to-day roles.
# Meeting program

## NRM Divisional Meeting

**Tuesday 13 – Wednesday 14 May 2008**

**Esplanade Hotel Fremantle**

### Tuesday 13 May

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>0830</td>
<td>Registrations, arrival tea/coffee</td>
</tr>
<tr>
<td>0900</td>
<td>Welcome</td>
</tr>
<tr>
<td>0925</td>
<td><em>Where we are going: Where does NRM fit in the bigger picture? Where are we headed?</em> - Director General Ian Longson. Importance of agriculture to WA and its ongoing development. Role of DAFWA in agriculture and the importance of natural resource management.</td>
</tr>
<tr>
<td>0950</td>
<td><em>Strategic direction for the NRM Division</em> - NRM Executive Director David Hartley. The end result NRM is working toward, what we must do to achieve it and where we are now.</td>
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<tr>
<td>1010</td>
<td>Questions/discussion</td>
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<tr>
<td>1035</td>
<td>Morning tea/posters</td>
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<tr>
<td>1100</td>
<td>Plenary session - Sirius Room</td>
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<tr>
<td>1100</td>
<td><strong>Who we are:</strong> How the NRM Division is structured and the focus of our branches</td>
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<tr>
<td>1130</td>
<td>Presentations by NRM Division Branch Managers</td>
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<tr>
<td>1200</td>
<td>Lunch/posters</td>
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<tr>
<td>1330</td>
<td>Concurrent session 1</td>
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<td>Concurrent session 2</td>
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<td>1455</td>
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<td>Plenary session - Sirius Room</td>
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<td><strong>Who we are:</strong> NRM work in the rangelands and agricultural regions</td>
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<td>Presentations by Rangelands and NRM Regional Managers</td>
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<td>Questions/discussion</td>
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<tr>
<td>1700</td>
<td>Summarise day/reflection</td>
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<td>1800</td>
<td>Dinner and drinks at the Esplanade Hotel Resort Pool</td>
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### Wednesday 14 May

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<tr>
<td>0830</td>
<td>Welcome</td>
</tr>
<tr>
<td>0845</td>
<td><em>Emerging Policy issues: NRM in Agriculture</em> - Eric Wright</td>
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<tr>
<td>0915</td>
<td>Questions/discussion</td>
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<td>0930</td>
<td><em>State NRM Policy Directions &amp; the NRM Sector</em> - Ross George</td>
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<td>Morning tea/posters</td>
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<td>1040</td>
<td>Concurrent session 4</td>
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<td>1110</td>
<td>Concurrent session 5</td>
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<td>1140</td>
<td>Concurrent session 6</td>
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<td>Lunch/posters</td>
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<tr>
<td>1305</td>
<td>Feedback session (concurrent rooms)</td>
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<tr>
<td>1305</td>
<td><em>Where are we going? How can we get there? ‘Temperature check’ on the NRM Division’s strategic direction and what we need to do to achieve it</em></td>
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<td>Plenary session - Sirius Room</td>
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<td><strong>Conclusions</strong> - David Hartley</td>
</tr>
<tr>
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<td>Evaluation</td>
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<tr>
<td>1500</td>
<td>Afternoon tea/posters</td>
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## Concurrent Sessions:

**Tuesday 13 May**

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<tr>
<th>Time</th>
<th>Sirius Room</th>
<th>Pleiades Room</th>
<th>King Sound Room</th>
<th>Admiralty Gulf Room</th>
</tr>
</thead>
</table>
| 1330  | “Integrated farm forestry systems have little impact on salinity” - Don Bennett  
*Long-term data from 24 sites show that the proportion vegetated (PV) is the most significant factor influencing groundwater reduction. PV levels required for significant on-farm salinity benefit far exceed the proportion of land affected by salinity at hydrologic equilibrium and therefore questions the tenet that integrated farm forestry (or revegetation) is a valid salinity tool.*  
*Adoption of saltland pastures: a case study of the SGLS WA Producer Network* - Jamie Bowyer  
*The participatory methodologies employed through the ‘Sustainable Grazing on Saline Lands - WA Producer Network’ were evaluated to determine their influence on landholder decision-making capacity and adoption of the saltland pastures. This presentation summarises what worked and what didn’t.*  
*“Latest developments in the accessing and using DAFWA land resource mapping data” - Dennis van Goor  
*A brief review of the information accessible, some traditional uses, new developments in data delivery for strategically important agricultural areas, and use of soil data for crop yield modeling.*  
*“Rangeland assessment” - Sandra Van Vreeswyk  
*This provides an introduction to WA's rangelands and the pastoral industry. It describes the assessment of range condition and outlines the NRM issues that occur on pastoral leases.*  
|       | Danielle England (chair)  
|       | Rachelle Crawford (chair)  
|       | Angela Stuart-Street (chair)  
|       | Adam Litticrap (chair)  |
| 1400  | “The agroforestry challenge: S and the environment” - Rob Sudmeyer  
*For medium and low rainfall areas finding economically competitive tree crops remains problematic. Changing policy, particularly on climate change, carbon sequestration and biofuels, provides new opportunities. The challenge is to provide robust information about the productivity and environmental benefits of agroforestry so that appropriate development can occur.*  
*“Assisting growers adapting to saltland. Integrating engineering and agronomy in the south-west” - John Paul Collins  
*Following conclusion of the Sustainable Grazing of Saline Lands project, the need arose to extend lessons learned to the wider farming community. Funding from the South West Catchments Council helped initiate demonstration sites in the Blackwood catchment to improve productivity of saline land.*  
*“Soil mapping using multiple lines of evidence” - Bill Verboom  
*A large soil mapping exercise was conducted to provide the best possible regional-scale information. This talk summarises the approach used and highlights some technological weaknesses encountered and improvements that can be made.*  
*“Ecologically Sustainable Rangeland Management program” - Luke Bayley  
*This works with land managers to balance production and environmental demands. The process is designed to capture existing knowledge and bring in technical expertise as required. It results in a mapped property plan, followed by development of an action plan which identifies factors that drive landscape function, biodiversity and livestock productivity.*  
|       |  
| 1430  | “The Resource Condition Monitoring project and results of analysis of the long-term groundwater trends” - Richard George  
*Over the past 20 years we have monitored groundwater levels to help forecast the potential for salinity in WA. In 2008 we undertook the first ever review of trends driving risk and the ‘Gaps’ project – the drilling of almost 400 new bores in areas of data pauvity.*  
*“Issues and processes of adoption of perennial pastures in the south-west low to medium rainfall zone” - Ned Crosley  
*Focus groups and semi-structured interviews have revealed many issues underlying adoption of perennial pastures in medium and low rainfall areas. The presentation covers the main issues we can influence and outlines strategies identified to address them.*  
*“Planning for impact in catchments: beyond incentives to technology development” - John Blake  
*This reviews the investigative and consultative processes used to determine priorities in the NRM investment framework of the South Coast. It also examines likely modes of investment in land systems after 2008, based on upgrading the framework and focus on assets at risk.*  
*“Mission impossible: ‘precision pastoralism’ for sustainable profits?” - Greg Brennan  
*Precision Pastoralism’, once considered a pipe梦想, is now in full swing in the southern rangelands, improving land condition, soil carbon and livestock production. New how pastoralists, working with DAFWA and commercial providers, are implementing land and livestock management formerly thought impossible on extensive pastoral stations.*  
|       |  

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### Concurrent Sessions:
#### Wednesday 14 May

<table>
<thead>
<tr>
<th>Time</th>
<th>Sirus Room: Mike Clarke (chair)</th>
<th>Pleiades Room: Cengiz Erol (chair)</th>
<th>King Sound Room: Susie Murphy-White (chair)</th>
<th>Admiralty Gulf Room: David Stanton (chair)</th>
</tr>
</thead>
</table>
| 1045  | "The role of land resource information in achieving sustainable land use" - Noel Schoknecht  
Providing good land resource information, which logically should inform, influence and improve management, on its own rarely leads to better management of the resource. This presentation examines the role of land resource information in achieving sustainable land use goals.  
Groundwater responds by declining in a drier climate in the Northern Agricultural Region" - Russell Speed  
Prior to 2000, groundwater levels were generally observed to be rising or at equilibrium. Since 2000, declining groundwater trends have been observed irrespective of geology, depth to groundwater or land management.  
"Determination of the ability of pastures to reduce nitrate-N leaching" - Ahmed Hassan  
We determined the micro-climatological parameters for water balance and measured the soil water and NO3-N under annuals, perennials and tagasaste. Perennials and tagasaste used more water and NO3-N leaching.  
"Environmental assurance and Western Australia’s broadacre industries - gaining the marketing edge" - Danielle England  
Farming for the Future is working with industry organisations, regional catchment councils and other agencies to develop recommended practices for WA’s broadacre industries. This presentation outlines how these on-farm practices align to production standards set by multi-nationals and other government agencies. |
| 1115  | "Planning for project impact" - Jenny Crisp  
Three core elements that must be considered in successful planning for impact are (i) the level of change your project intends to bring about, (ii) target audiences for change, as opposed to other stakeholders such as partners and funders, and (iii) choosing extension activities that are consistent with the identified level of intended change. The presentation also highlights the broad focus of contemporary extension.  
"Acid groundwater in the south-west of Western Australia: it’s distribution, causes and implications for agriculture" - Adam Lillrac  
Acidification of inland waters was identified as a threat in the 2007 State of Environment Report. Agricultural drainage for salinity management is a significant contributor to acidification in the dryland agricultural areas. Discussion of acidic groundwater distribution, potential causes, agricultural impacts and management.  
"Reducing nitrogen and phosphorus leaching from concentrated cattle feeding operations using foaming-pad bioremediation" - Robert Routa & Craig Russell  
Dairy herds are becoming bigger and the potential for point-source pollution could escalate into a serious issue. One approach involves confining milkers to a GreenPad of sand over coarse wood chips. This significantly reduces nitrate and phosphorus leaching from high density urine and faecal deposits.  
"Setting catchment and regional scale targets for salinity in the South West NRM Region" - Heather Percy  
The South West Region NRM Strategy contains a provisional resource condition target on land salinity, which is time-bound but not specific. This paper outlines processes to set salinity resource condition for priority catchments and at regional soil-landscape zone scale. |
| 1145  | "Climate change - DAFWA policy & research activities" - Eric Wright  
Overview of the recently-formed DAFWA Climate Change Reference Group, which has been set up to help coordinate climate change activities across the Department.  
"Waterwise on the Farm project" - James Dee  
WaterWise is about helping increase the sustainability of irrigation water use. This project has evolved from a simple pilot in 2002 into the complex project that operates today.  
"The Greener Pastures project – a good model for effective NRM integration with industry?" - Don Bennett  
Greener Pastures, with focus on increasing farm profits and safeguarding the environment through smarter nutrient use, is an example of a project that is achieving strong farmer engagement with environmental issues.  
"Modelling reliable runoff from farm-scale catchments" - Tilwin Westrup  
Runoff for water supplies is governed by rainfall, vegetation and catchment characteristics. DAFWA soil-landscape mapping can be a surrogate for these characteristics, and allow us to model runoff from farm-scale catchments for rainfall scenarios over large areas independent of gauged data. |
Concurrent session presentations from staff

Long-term monitoring shows that integrated farm forestry has little impact on salinity

Don Bennett and Richard George; don.bennett@agric.wa.gov.au

Since the mid-1980s, farmers have been encouraged to revegetate cleared agricultural land to reduce groundwater recharge and the area of dryland salinity. Adoption has been influenced by the success of extensive commercial forestry trials in high rainfall, water supply catchments where groundwater and salinity levels were lowered by almost complete reforestation (Schofield et al. 1989) and the attractive prices paid by companies where whole farms are converted to trees. However, where smaller proportions are planted because the dominant income is from agriculture, farmers are becoming increasingly reluctant to plant extensive areas to control salinity without better knowledge. In particular, farmers want to know how much revegetation will be required and in what format it should be planted to reduce their risk and extent of salinity. They are also requesting guarantees on likely financial returns from farm forestry so they can better analyse the cost-benefit. Additionally, governments are investing in the development of a farm forestry industry (Anon 2005). Salinity management is proposed as a major outcome of both public and private schemes.

George et al. (1999) reviewed all available watertable response data from a wide range of sites in Western Australia. While many of their 80 sites were not designed to affect salinity and some were at a comparatively early stage, they concluded that: trees are best planted in recharge areas; discharge plantings rarely reclaim saline areas; responses are generally confined beneath the planting; and extensive plantings (perhaps influencing 80% of the landscape) are required to significantly reduce watertables and the area of salinity. Despite these findings from almost a decade ago, the promotion of salinity-focused, small, so-called integrated farm forestry systems has continued.

To improve our predictive capacity to forecast the effect of integrating trees in agricultural landscapes on groundwater levels and salinity, and update earlier work, trials established on 24 sites within discrete groundwater catchments on 15 farms between 1990 and 1996 in south-western Australia, were analysed. These trials were mostly within upland catchments, using a range of designs such as contour belts, linear and contour alleys, blocks and targeted plantings in hydrologically discrete areas. The area planted varied from almost complete revegetation (over 98%) to less that 5% (on or near saline seeps).

Methods

The sites investigated (Table 1) are all within the medium rainfall (500-800 mm) ‘woolbelt’ south-east of Perth. Groundwater systems are local-scaled and formed within weathered Archaean granitoid regolith (which at some sites is overlain by Cenozoic sediments) 2-40 m deep. Sites were cleared for agriculture between 1935 and 1981. At most sites the planting design (area, layout, species etc) was developed by the landholders in consultation with plantation managers, Landcare officers and hydrologists, using the best available knowledge. However, ultimately the landholder selected the final design on practical considerations. The revegetation comprised various proportions of commercial forestry species, mainly Eucalyptus globulus, E. saligna and Pinus pinaster as well as mixtures of salt-tolerant species such as E. camaldulensis, E. occidentalis and Casuarina spp. in discharge areas.
The ‘watertable response’ to revegetation was calculated from regular measurements from 226 piezometers and observation bores. These were installed at, or just prior to, the time of planting using a rotary air-blast drilling rig. At many sites multiple depth bores were installed so that groundwater salinity profiles and aquifer pressure relationships could be determined. The responses reported are for between 10 and 21 years following revegetation.

Changes in saline areas were determined by a combination of site inspection and interpretation of aerial photography. The possible influence of rainfall variations was determined by comparing the accumulative monthly residual rainfall (AMRR) during the period of investigation, with the AMRR from 1975 onwards at a number of locations within the study area. Because AMRR remained similar for both time periods rainfall variability was determined not to be a major influence on watertable response.

Results and discussion

Regression analysis was undertaken between the proportions of the catchment vegetated (PV) and the mean change in watertables both within the revegetated area and within the adjacent, untreated (downslope discharge) area. Figure 1 shows that PV accounts for 49% of variability in watertable response within the revegetated area (P <0.0005). Within this area, maximum mean watertable response to revegetation was -5.26 m at the Uren site (98% vegetated, Table 1), with near zero response at CochraneSA (saline valley, alley revegetation on <0.1% of a larger catchment).

The relationship between PV and response indicates that more than 50% PV is required to reduce watertables by more than 2 m beneath the revegetation system for all forestry layouts. The maximum observed variability (of approximately ±2 m) is modest given the range of factors that could be expected to influence response across all sites and indicate that PV is likely to be the major influence. Inclusion of watertable salinity and aquifer gradient (an indicator of transmissivity) with PV to the relationship explained an additional 5% of variability.

Watertable response in adjacent, downslope, untreated discharges was minor and not as well correlated with PV (P <0.01; described 38% of variability). For example, at the Uren site which has >98% PV the response in a bore within the discharge located 100 m from the lower edge of the plantation was -1.1 m. At PVs of between 30 and 50% responses ranged from -0.7 m to +0.16 m, with no reductions greater than 0.3 m for PV <30%. These results are not surprising given that the limited watertable reduction caused almost no change in groundwater gradients (Table 1). Even small quantities of recharge occurring in situ and in adjacent unplanted areas could provide enough groundwater to maintain watertables given modest (if any) groundwater through-flow reductions from the upslope plantings.

Revegetation resulted in small reductions of saline land at five sites (Table 1), although at four of these the revegetation extends into the saline area. However at three sites, salinity increased during the period of revegetation. Of the 16 sites with no obvious change in the area of salinity, five had apparent reductions in severity. At all of these sites it is likely that changes in agricultural management, such as controlled grazing and introduction of perennial and other salt-tolerant pastures (often facilitated by re-alignment of fencing during tree establishment) were responsible for the improvement.

Visual assessment of the extent of salinity further downslope at the confluence with the next, adjacent catchment showed no reduction attributable to the revegetation at any site (Table 1), suggesting that land salinity benefits are likely to be localised near areas of revegetation.
Table 1. Site characteristics and results

<table>
<thead>
<tr>
<th>Site</th>
<th>Post-1975 a.a.r. (mm)</th>
<th>No. of bores</th>
<th>Record length (years)</th>
<th>Revegetation age (year)</th>
<th>Watertable salinity (mg/L)</th>
<th>Catchment area (ha)</th>
<th>Remnant vegetation (%)</th>
<th>Revegetation (%)</th>
<th>Total vegetation (%)</th>
<th>Revegetation layout</th>
<th>Landscape position of revegetation</th>
<th>Mean watertable response within revegetation (m)</th>
<th>Mean watertable response downhill (m)</th>
<th>Groundwater gradient at commencement (%)</th>
<th>Groundwater gradient in 2007 (%)</th>
<th>Area of salt (change)</th>
<th>Severity of salt (change)</th>
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la = linear alley, b(s) = block(s), cb = contour belt, ca = contour alley; ~ nc = no change, r = reduction, i = increase; # l = lower slope, m = mid slope, c = entire catena, u = upper slope, @ ne = new equilibrium, nt = no trend, lr = linear reduction.
Twenty-five years is considered the maximum practical planning horizon for most land managers, and coincides with approximately two rotations of a pulp timber forestry regime or a (projected) single rotation of a sawlog management regime. Because many of the sites in this study are younger than 25 years, the temporal pattern of watertable response was examined to determine if further reductions in watertables are likely (Table 1). At 14 sites ‘new equilibrium’ groundwater conditions appear to have been reached (e.g. Wardle1, Figure 2) meaning further response would not be expected. This may be because the vegetation has achieved near maximum water use at canopy closure (close to maximum leaf area - known to be a good surrogate for water use), and/or the catchment is at a new hydrologic balance. It also indicates that the vegetation has most effect on reducing recharge, and does not indicate any significant transpiration of groundwater. Of the remaining six sites with ‘no trend’, two were indeterminate and only two sites (Ritson1 & 2) had ‘reducing linear’ trends, indicating that further reductions are possible.
In addition to the responses measured it may be argued that revegetation may have prevented additional watertable rises had the areas not been planted. To assess this we examined the average change in watertable in control bores (13 sites) and found this to be -0.06 m, with a range of -0.66 to 0.52 m. These data and the observation of mean time since clearing (45 years) suggest that either most sites were at or near equilibrium, or that revegetation may have brought forward the date of equilibrium slightly.

Conclusions

- At the 24 sites measured, PV is the most significant factor influencing groundwater reduction, with large PVs in any design or layout required to produce large reductions in groundwater levels beneath trees.
- Reductions are localised beneath the revegetation system, with little impact on measured groundwater levels or extent of saline land, either immediately downslope of the revegetation or at the confluence of adjoining catchments at PVs <98%.
- Typically, <50% PV is unlikely to result in significant, measurable on-farm salinity benefits.
- PV levels that are high enough to provide significant salinity benefits at the farm scale are unlikely to be attractive to ‘mainstream’ farmers unless the relinquished annual income derived from agriculture is at least replaced by annual income derived from the revegetation.
- PV levels required for significant on-farm salinity benefit will be far in excess (three to five times) of the proportion of land affected by salinity at hydrologic equilibrium.
- Regional to catchment-scale stream salinity benefits may accrue at moderate PVs through reduced discharge, however at sites studied here, this appears unlikely given the PV, limited reduction in gradient and saline area; this benefit could also be counter-balanced by the reduction in fresh runoff.
- The bulk of the hydrologic impacts appear to have been reached after 10 years of revegetation, some 15 years before harvest for some tree crops.
- The generally limited watertable and salinity impact at low PV is of similar magnitude to that reported in George et al. in 1999.

References


Adoption of saltland pastures: a case study of the SGSL WA Producer Network

Rebecca Heath, Jamie Bowyer & Trevor Lacey; rebecca.heath@agric.wa.gov.au

As some Western Australian wheatbelt farmers watch their land and income succumb to dryland salinity, the urgency for the development and adoption of productive and profitable options for saline land is increasing. However, the uptake of practices that reduce risks has not been as widespread as anticipated. Participatory research and development (PRD) is one approach that can be used to create change. The WA Producer Network, a key component of the national Sustainable Grazing on Saline Lands (SGSL) initiative, supported a process of ‘continuous discovery’ through a network of grower groups in the south west agricultural zone. Each group hosted a PRD project for sustainable grazing on saline land. The intent was for groups to identify key issues relating to their use of saline land, explore options and solutions, and share the information across the network. Overall, the project endeavoured to show producers that saline land can be a profitable asset.

The key PRD elements employed through the WA Producer Network included monetary grants, participatory trials including site monitoring, provision of technical and other support, development of an information exchange network, provision of written material (technical and case study), and host groups to broaden the network and provide further support for the sites. These elements were evaluated to determine their influence on farmer decision-making capacity and subsequent adoption of saltland pasture systems.

Semi-structured interviews (SSI) were conducted with 25 of 67 farmers hosting an SGSL site on their property (host farmers). This is a qualitative technique that provided a ‘rich picture’ from which themes for further analysis were identified.

What worked and what didn’t

From this evaluation, the SGSL WA Producer Network appeared to have built the internal capacity (knowledge, attitude, skills, aspirations and confidence) of the host farmers to a point where decisions to adopt or not adopt saltland pasture systems could be made. Although the host farmers’ level of prior experience influenced the impact of the project on them, it nonetheless appeared to have ‘primed’ them for further saltland work, and the participatory approach was valuable in achieving this.

What worked:

Four elements played a key role in building capacity of the host farmers: the host farm participatory trial sites; provision of technical and other support; opportunities to interact with other farmers, scientists and industry experts; and monetary grants given to host farmers to establish sites.

Participatory trial sites – The trial sites established and managed by the host farmers played a central role in building knowledge, skills and confidence, with 80 per cent of the farmers interviewed believing the sites were the most important aspect of the project in building their confidence. They were able to learn first-hand what worked and what didn’t on their farms. This knowledge, with the skills learnt by “getting their hands dirty”, helped to develop confidence in the saltland pasture systems trialled and management of salt-affected areas in general. The value of actually ‘doing’, in terms of building capacity, was highlighted, and should be an important consideration for projects that focus on practice change.

Provision of technical and other support - Support provided to farmers throughout their projects was valuable in building knowledge, skills and confidence. Most host farmers interviewed found it helpful to have the expertise of the SGSL team and others to draw upon.
The SGSL team in particular played an important role in delivering ‘on-ground’ information that increased awareness and knowledge among the host farmers as well as aiding the development of new skills and building host farmer confidence. It is clear that strong relationships developed between members of the SGSL team and most host farmers interviewed.

“They have got a good core group of guys that oversee the project who are keen on what they are doing, and know what they are talking about, and actually do physically get out in the paddock and make sure they are out there to see the sites. So that makes a hell of a difference when you have got that.”

The level of support varied across host farmers. For example, 10 farmers regularly received support with monitoring their sites, while seven suggested no support was obtained. Although certain aspects of support were highly valued, other aspects were not valued due to lack of feedback, timeliness, being unsure as to who to contact and/or because expectations were not met. Nevertheless, the support received was highly valued and often mentioned as a key aspect, especially where the level of support received was above expectations.

Opportunities to interact with other - Opportunities to interact with others involved in saltland management were highly valued by 64% of those interviewed and played an important role in building capacity. It is interesting to note that, to the host farmers, the major forums for technical information exchange (such as field days, seminars and events) were as much about interacting with other farmers in similar situations and technical experts as they were about accessing information. The farmers clearly enjoyed the interaction and were able to gather useful information. The host farmers interviewed placed a greater value on information received from or about other host farmers. This highlights the value of farmer-managed sites as an extension tool, but also comments on the perceived credibility of information sources.

“Mainly I prefer a lot of the time to speak to farmers because they are in the same business that I am in, and sometimes they will throw in a different question that you haven’t thought of, come at it from a different angle. So that is quite good…blokes that are living the problem.”

The monetary grant - Without grants to establish trial sites, much of the advances in capacity would not have occurred. The grant played an important role in drawing farmers into the network. It also allowed them to do in one season what would have taken a number of years. For the less experienced farmers, the grant provided opportunity to begin saltland pasture work they had been planning, or motivated them to do something that they had been thinking about but hadn’t got around to. The grant also reduced the risk and costs involved in trialling technologies. Some more experienced farmers used the opportunity to help finance the next paddock of saltland pasture, while others used funding to discover ways to improve on what they had been doing. Without the grant, half of the host farmers interviewed would not have become involved, lessening the likelihood of them developing the levels of capacity achieved in the timeframe of the SGSL WA Producer Network.

What didn’t work: Elements that appeared to play a lesser role in building farmer capacity were the written material provided, site monitoring and involvement of a group.

Written material - This did not seem to be highly influential in developing capacity; however it was of some value to half of those interviewed. Information about other sites, rather than technical information, was considered most valuable as host farmers found it interesting to read what was happening elsewhere and get other farmer perspectives. An interesting point is that two farmers who weren’t able to get to any field days or forums found the written material about the other trial sites one of the most valuable aspects of the project, further demonstrating the value farmers place on information from other farmers.
Site monitoring - The level of site monitoring varied considerably. Three were not monitored at all; 12 were monitored regularly by the farmer and/or SGSL; and minimal monitoring or preliminary monitoring only, occurred on nine sites. Twelve host farmers did not have a positive reaction to this activity but thought that it could have been valuable if done differently. In general, host farmers felt that the proposed monitoring was too much and too complex. Discussion to identify valuable information beforehand would have been useful; as would discussions to clearly define what (if anything) the landholder would be expected to contribute.

“I think we know barley grass is worthless and I think we know that better coverage of whatever – a legume or other grasses – every farmer knows that it is much better feed value….we don’t normally have to get down on our hands and knees and cut them off and weigh them.”

Host groups - Although each trial proposal was submitted through a grower (host) group in order to broaden the network and further support host farmers, group involvement was variable. It ranged from strong involvement throughout the life of projects to attendance only at field days and/or input into development of the site, to no involvement at all. It was also apparent that 18 host farmers used the name of any group for their application, with no real intent of working with that group. For these reasons, it is difficult to assess what impact groups had on the capacity of the farmers interviewed. From the host farmers’ perspective, where groups were active they added to the overall support for the site. One farmer commented that his group provided motivation and reassurance. This type of support may improve host farmer knowledge, skills and confidence by guaranteeing progress.

Impact on adoption: In order for host farmers to decide on whether to adopt new practices or not, they must first have the appropriate capacity required to make change. It is clear that the SGSL WA Producer Network was instrumental in developing the capacity of the host farmers interviewed to a point where these decisions could be made. However, being able to make these decisions does not necessarily mean that adoption has, or will, occur. Finances, time available to implement change, availability of saltland and seasonal conditions were identified through the interviews as other factors that influenced adoption. Nevertheless, most host farmers believed involvement in the project had some influence on adoption decisions, and many plan to establish, or already had established further areas of saltland pasture. Broadly, the project has accelerated farmers along an adoption pathway, as participants have been able to quickly build skills, knowledge and confidence, leading to the ability to make decisions. In addition, anecdotal evidence suggested the network had some influence on adoption of/interest in saltland pasture systems beyond the host farmers.

Conclusions

Overall, the SGSL WA Producer Network has had a positive impact upon adoption and/or the decision-making capacity of the host farmers interviewed. The participatory approach was valuable in preparing the host farmers for further saltland work, although the farmers’ level of prior experience with saltland pastures did influence the impact of the project. Other factors including time, finances, availability of saline land and seasonal conditions prevented some farmers from establishing additional areas immediately. While the hands-on experience gained through the trial sites was critical in improving knowledge, skills and confidence, the opportunities to interact with other host farmers and ‘experts’ appeared to be the most valued aspect.
Latest developments in accessing and using DAFWA land resource mapping data

_Dennis van Gool and Peter Tille; dennis.vangool@agric.wa.gov.au_

It has been a function of natural resource management within the Department of Agriculture and Food to compile soil and landscape information and mapping over many years. In the early 1990s we realised the importance of maintaining our information in a highly structured relational database so that we can prepare meaningful land resource summaries anywhere in the south west agriculture region. But how do we do this?

Soil-landscape information, similar to other natural resource data, is highly variable, complex and often difficult to quantify. In WA we were fortunate enough to combine the skills of computer literate soil surveyors and database experts. Through this collaborative effort the data attached to the mapping are now the most comprehensive in Australia. The quality of our database is a message I have been spreading for some time, but only Queensland has managed to compile many surveys into a useful database framework. But because they have not addressed inconsistencies across surveys their information is considerably more difficult to use. Consequently, CSIRO are now trying to compile soil surveys nationally under the Australian Soil Resource Information System (ASRIS), which is structured very similarly to WA data1. This is important because it puts us at the forefront in land resource research that uses soil or soil-landscape mapping. Anything we can do here, they should be able to do elsewhere….eventually1. WA’s mapping is far from perfect, but it’s a very good start.

It’s worth noting that our soil-landscape mapping represents a compromise between costs, technology available and the perceived map requirements at the time. Even our best mapping has considerable uncertainty, and there is only a partial relationship between the soil profile sites and the discrete mapped areas marked on our maps. This is because much information is decided by the surveyor ‘on the fly’ using things like aerial photographs and satellite images. The profile sites are only a small additional evidence layer in this process. There is a need to improve and to quantify surveys whenever possible. Hence we have a ‘living database’ that requires maintenance to remain valuable. We are constantly updating the rules for mapping, the underlying data and the methods employed to improve our map data. Bill Verboom’s update of the mapping in the eastern wheatbelt is an exciting example of a significant improvement to the mapping over a vast area using remotely-sensed information and new mapping techniques.

Over the years the method for delivering land resource mapping and data has progressed from published maps and reports through individual computer-generated reports and CD-ROMs to web-based products. WA is lucky as the general public has internet access to much detailed soils information via the Shared Land Information Platform (SLIP). This ensures access to the most current versions of our rapidly evolving mapping and data.

CD-ROMs include AGMAPS, and recent land resource publications include intelligent CD mapping. These CDs have been partly superseded by SLIP but also contain published information not available on SLIP, and, like a book, they effectively date-stamp the information at that time.

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1 There are regions with excellent data, however, statewide consistency in much of Australia is a long way off. The exception is SA, which maintained consistency of published surveys and has now used ASRIS to compile this land resource data into a functional database.
The most exciting advance is web-based delivery of our mapping via SLIP and ASRIS. ASRIS is focusing on national data acquisition and there are no good interpreted products available directly from ASRIS (yet). Despite being hugely valuable as a national resource inventory, the information is currently very technical and quite cryptic even for many soils specialists. This is because developing useful interpretations is not straight forward and has not been budgeted for yet.

Fortunately the soil information on SLIP has many derived maps, which all come from the same database. The SLIP information includes a survey index, which indicates map reliability, map scale and the published source of the information. This information indicates that even at the most detailed scale on-site investigation is usually warranted. However the mapping can often reduce the amount of investigation required.

Mapped information is in a hierarchy which includes soil-landscape zones, systems, subsystems and phases. Soil and landscape information is proportionately attached to the subsystems and phases and can be aggregated to present at any level in the hierarchy.

The uses to which this is being put are growing, and include everything from farm or property level assessments to broad regional policy and planning advice. We are only just scratching the surface for the potential uses.

As the soil and landform data underlying the maps continue to evolve, so do the uses to which they can be put. While traditional uses such as strategic planning (including local rural strategies and regional strategies planning policies), catchment planning, land capability assessments and degradations risk mapping will continue, more innovative uses are appearing and include:

- Integration with remnant vegetation and vegetation communities
- Investigating the spread of weeds
- Runoff modelling
- Nutrient pollution and eutrophication of waterways
- Investigating the fate of pesticides in the environment.

It could be argued that that our delivery of the data has had mixed influence. Though there have been many positive outcomes, information can be used many ways, and there are also many examples where our information has been used effectively to undermine natural resource management (NRM) or agricultural industry outcomes.

One example occurs because the real estate industry and planning specialists look to the information for advice. There are many cases where valuable agricultural land has been subdivided because the “capability of the land” will not result in increased degradation - without fully considering the implications for the industry and region as a whole. This results in increased pressure on shires and planners to service these areas and sub-optimal outcomes for agriculture, though not necessarily for NRM.

With the advent of SLIP, our challenge is to use the information effectively to benefit agriculture and NRM. Below are two examples we are currently working on.

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2 The old Land and Water Audit information is available, but soil themes for WA are unreliable and only useable for very big picture summaries at best.
Identification of strategically important agricultural areas

On the South Coast and the South West the Department has begun to develop strategically important agricultural areas. The aim is to combine many complex themes to consider the higher level planning requirements for an agricultural area, rather than just providing advice based on land capability alone. Peter Tille has developed a methodology that combines various land capability themes and also considers water information in the assessment. Next we will use existing parcel size and detailed land use information, currently being updated by CRIS. The final step is to undergo a consultation phase, probably via a Government Officers Technical Advisory group. An objective is to make this process easy to repeat throughout WA and to present the resultant maps on SLIP. Probably the main block at the moment is that regional water information, unlike the soil-landscape information, is not readily available from a database.

Crop yield modelling

There are strong NRM implications for improved yield modelling, particularly in the face of climate change and the continuing cost price squeeze. We are beginning to build a better picture of these implications for the industry, the community and the environment.

Our initial work was very simplistic seasonal rainfall-driven yields, scaled by land capability, so that good land yields more, and poor land yields less (e.g. see White et al. 2006, van Gool and Vernon 2007). Hence, for example, saline valley floors have low yields, even when rainfall is adequate.

We are now working in a large crop industry project (LOOP - Lupins Oilseeds Oats and Pulses) on linking our soils information with APSIM (Agricultural Production Simulator). APSIM is very data hungry, but to keep things manageable we grouping about 700+ soils in our database into 10–20 APSIM-friendly classes, with similar plant-available water and rooting depths. We are also looking at broad classes for major seasonal variation, e.g. is there early or late rain etc. If we are successful, this soil and climate data will allow us to explore issues such as the yield and cost implications of seasonal variation and climate change. This will give much more realistic assessments of how different NRM (and other) policies might impact agricultural production.

Conclusion

Soil-landscape information, like much NRM information, is generally complex, can be difficult to quantify and requires ongoing development and maintenance to remain current and relevant. New technology and creative researchers are helping to improve information at an increasing rate.

The SLIP website and soil-landscape information is a great opportunity to make data widely available, and to promote NRM outcomes. Resource information can be used for many purposes and good information does not equal good decision-making. NRM needs to get on the front foot to develop and promote information products to benefit agriculture. A further benefit of active involvement – rather than just supplying data - is feedback, which will benefit the ongoing development and maintenance of the data.

WEB addresses

APSIM: http://www.apsim.info/apsim/default.asp
Further reading


See the internet window that pops up when you enter the soil-landscape mapping on the SLIP page.
Rangeland assessment

Sandra Van Vreeswyk; sandra.vanvreeswyk@agric.wa.gov.au

Pastoral stations cover 89 million hectares or 36 per cent of Western Australia and range from tropical grasslands in the north through to arid shrublands in the south, with annual rainfall ranging from 1,400 mm in the north Kimberley to less than 200 mm on the Nullarbor Plain. There are 470 pastoral stations, ranging from 6,500 to more than 590,000 ha, with an average size of 185,000 ha.

Pastoral stations are used for open range grazing of livestock on native vegetation, and are State land held under pastoral lease. The northern rangelands are used predominantly for cattle production for the export market. The southern rangelands were traditionally used for wool production but poor returns have led to many pastoralists to change to cattle, meat sheep or goats over the past 20 years. Annual pastoral production is around $200 million: $140m in cattle sales, $34m in wool production; $14m in sheep sales and $12m in goats. Pastoralists continue to work with the relevant agencies to explore new opportunities for diversification, such as irrigated fodder production and tourism.

Pastoral lessees comprise: 48% individual/family; 29% corporations; 12% Aboriginal groups; 10% mining companies; and 1% private conservation companies. Stations turn over at around 5% per year. There is strong market demand for viable cattle stations in the northern rangelands. In the southern rangelands there is increasing demand for smaller, non-viable lifestyle stations with the station used as a residence and the lessee working off-station, most commonly for nearby mining companies. The number of stations has continued to decline over the last decade, mainly because of purchases by the Department of Environment and Conservation for the nature conservation estate.

The presence of a viable pastoral industry ensures the continuation of communities in remote areas through provision of people, culture, employment and infrastructure.

Rangeland condition assessment

A combined team from DAFWA and Landgate conducts regional resource inventory and condition surveys in the rangelands. The surveys provide a comprehensive description and mapping of landforms, soils and vegetation resources, together with an evaluation of the condition of the soils and vegetation at the pastoral station scale. Almost 95% of the pastoral rangelands have been surveyed. The resource information is used by many stakeholders including the pastoral industry, mining, government, research and conservation groups.

In each regional survey thousands of subjective visual assessments of range condition (the grazing impact on perennial vegetation and soils) are made at one kilometre intervals along pre-selected traverse routes. Signs of grazing impact include the loss of palatable species, increase in unpalatable species, and accelerated soil erosion. The assessor must have an understanding of the landscape/vegetation associations to determine what plants could be expected to occur in a particular location, and of the indicator value of plants under grazing pressure. Because only the perennial vegetation is considered, the long-term range condition, not the seasonal condition, is assessed.

Carrying capacities are recommended for each vegetation type in good, fair and poor range condition. Table 1 summarises range condition from regional rangeland surveys.
Table 1. Rangeland condition estimated from surveys

<table>
<thead>
<tr>
<th>Region (and year commenced)</th>
<th>Total area (km²)</th>
<th>No. of traverse assessments</th>
<th>Severely degraded and eroded area (km²)</th>
<th>Range condition (% of traverse assessments)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gascoyne (1969)</td>
<td>63,400</td>
<td>2,426</td>
<td>1,205*</td>
<td>Good 32, Fair 53, Poor 15</td>
</tr>
<tr>
<td>West Kimberley (1972)</td>
<td>89,600</td>
<td>4,532</td>
<td>2,000*</td>
<td>Good 20, Fair 50, Poor 30</td>
</tr>
<tr>
<td>Eastern Nullarbor (1974)</td>
<td>47,400</td>
<td>1,273</td>
<td>0</td>
<td>Good 50, Fair 10, Poor 40</td>
</tr>
<tr>
<td>Ashburton (1976)</td>
<td>93,600</td>
<td>8,608</td>
<td>534</td>
<td>Good 50, Fair 34, Poor 16</td>
</tr>
<tr>
<td>Carnarvon Basin (1980)</td>
<td>74,500</td>
<td>10,952</td>
<td>647</td>
<td>Good 45, Fair 32, Poor 23</td>
</tr>
<tr>
<td>Murchison (1985)</td>
<td>88,360</td>
<td>13,441</td>
<td>1,560</td>
<td>Good 21, Fair 37, Poor 42</td>
</tr>
<tr>
<td>Roebourne Plains (1987)</td>
<td>10,216</td>
<td>1,172</td>
<td>233</td>
<td>Good 51, Fair 27, Poor 22</td>
</tr>
<tr>
<td>North-eastern Goldfields (1988)</td>
<td>100,570</td>
<td>10,470</td>
<td>452</td>
<td>Good 39, Fair 32, Poor 29</td>
</tr>
<tr>
<td>Sandstone-Yalgoo-Paynes Find (1992)</td>
<td>94,710</td>
<td>9,435</td>
<td>145</td>
<td>Good 45, Fair 32, Poor 23</td>
</tr>
<tr>
<td>Pilbara (1995)</td>
<td>181,723</td>
<td>12,448</td>
<td>310</td>
<td>Good 77, Fair 11, Poor 12</td>
</tr>
<tr>
<td><strong>All areas surveyed</strong></td>
<td><strong>844,079</strong></td>
<td><strong>74,757</strong></td>
<td><strong>7,086</strong></td>
<td><strong>Good 44, Fair 31, Poor 25</strong></td>
</tr>
</tbody>
</table>

* Not mapped, estimate only.

**Pastoral inspection program**

The Pastoral Lands Board administers pastoral land in WA. Its main role is to ensure that land is managed on an ecologically sustainable basis. DAFWA provides advice and technical support to the board under a Memorandum of Understanding.

DAFWA pastoral inspectors assess range condition on stations on a six-yearly cycle, and carry out more frequent follow-up inspections where land management issues have been identified. The report includes information on seasonal conditions, land systems, range condition, carrying capacity, stocking history, declared plants and animals, and comments on infrastructure. This allows the board to assess management and make directions on identified issues. DAFWA also provides advice on diversification permits, management plans, agistment and amalgamations.

Assessments of range condition during inspections are compared to previous assessments made during rangeland resource surveys or previous lease inspections to provide an indication of range condition trend. Some stations have not been covered by rangeland surveys, and in some cases a direct comparison cannot be made because the assessment route was significantly different, or the methodology used has changed (some surveys date back to 1969). Of the 288 stations where these comparisons can be made, 124 (43%) had a positive change in overall range condition with 20 indicating a large positive change, 44 indicated a moderate positive change and 60 a small positive change. Sixty-six stations (23%) had deteriorated in overall condition with two indicating a large negative change, 24 stations indicating a moderate negative change and 40 indicating a small negative change. Ninety-eight (34%) indicated no significant change in overall range condition.

Of 204 stations inspected between 2005 and 2007, specific land management issues were identified on 147 (72%). The most common issues were related to rangeland degradation; overstocking; inadequate infrastructure to control stock; lack of control of total grazing pressure; weeds; and altered fire regimes.
NRM issues on pastoral stations

Rangeland degradation most commonly occurs as a change in the composition of perennial plants as palatable species are removed and unpalatable species become dominant. Often the perennial plant cover is reduced, however in some cases cover is significantly increased as unpalatable plants increase and form dense stands. With less plant cover, soil surfaces are increasingly unprotected from the effects of wind and water and soil erosion may commence unless the surface is inherently stable.

Overstocking occurs where the distribution of stock and the intensity and length of grazing is such that vegetation cannot regenerate and rangeland is degraded. It is not necessarily related to the overall number of livestock, but to lack of control of their grazing impact. Stock control is essential because stock will preferentially graze some types of vegetation, thus over-using it. These are often drainage areas or run-on areas with fragile clay soils.

Infrastructure must be adequate to control stock and spread grazing impact more evenly. The distribution of watering points can ensure even grazing across paddocks, rather than overgrazing in some parts and under-utilisation in others. Strategic location of watering points can reduce preferential grazing on fragile areas by locating water a few kilometres away to make stock use poorer but more resilient country closer to the watering point.

Total grazing pressure, the grazing impact of feral animals and native herbivores as well as of livestock, must be managed. Feral donkeys, horses, camels and goats contribute to this. Kangaroo numbers have increased significantly since artificial water supplies became available through pastoralism, and they can prevent regeneration of areas through overuse.

Invasive weeds reduce land productivity and biodiversity. The most common reported weeds on stations are mesquite, Parkinsonia, Bathurst burr, horehound and saffron thistle.

Large scale wildfires and excessive use of controlled fires can radically alter the landscape by affecting plant community composition and biodiversity. Frequent burning can also lead to more soil erosion. This is of most concern on the grasslands of the northern rangelands.

Actions to address land management issues include: reducing stocking levels in dry periods; spelling; destocking; mechanical regeneration; maintaining or redeveloping infrastructure to spread grazing and control stock; managing total grazing pressure through trap yards that control feral animals and kangaroos; controlling weeds; and developing a fire management plan. A monitoring system is recommended to guide management decisions.

The future

DAFWA’s focus in the northern rangelands is on the potential for cattle production through improved productivity, improved pastures and the involvement of a greater number of indigenous properties in economic production. In the southern rangelands the focus is on sustainable productivity through better understanding and management of the fragile resource to achieve both production and range condition improvement.

The current pastoral inspection program is becoming unsustainable, using 10 FTEs and costing $1.2M annually, with costs escalating. The State collects $1.6M annually in pastoral lease rents, but it costs about $2.2M to administer pastoral leases. DAFWA is investigating a new model for rangeland assessment which will include a component of remote sensing in addition to ground-based assessments, and may move towards a self-assessment/quality assurance system for the pastoral industry. A self-assessment system will increase pastoralists’ understanding of the impact of their land management practices on the rangeland resource.
The agroforestry challenge: dollars and the environment

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It is almost a received wisdom that planting trees into agricultural landscapes is good for the environment. Government agencies (including DAFWA) and NGOs have been actively promoting revegetation to combat salinisation in WA for many years, initially under the Landcare ethos and more recently, as the scale and cost of the revegetation required has been recognised, as agroforestry plantings. While the last 15 years have seen a spectacular change in land use from pasture to plantation forestry in the high rainfall areas, agroforestry adoption has been poor; particularly in the medium and low rainfall agricultural areas. Arguably, the most important reasons for this have been the difficulties in clearly demonstrating direct environmental and financial benefits for landholders (Pannell 2001).

While other agencies have taken lead roles in researching the direct economic returns from tree crops, DAFWA has been actively researching the hydrological and tree/crop interaction benefits of agroforestry since the early 1980s. The critical research questions for DAFWA have been; defining and quantifying onsite benefits that can be captured by landholders as increased agricultural productivity and quantifying off-site benefits particularly as they relate to salinity management. Given the time required for trees to become established, much of this research has been long-term or relied on access to mature, or at least fully established, agroforestry systems. Consequently, there is often a lag between the time a new agroforestry system is proposed and plantings initiated, and research providing a full understanding of the productivity and environmental benefits of the system. However, we now have a better understanding of the hydrological impacts of trees and how trees and agricultural crops and pastures interact in the WA wheatbelt.

![Figure 1: Soil water content under agricultural land and 6 year-old Eucalyptus polybractea at Tincurrin, WA. Soil water deficit to 10 m was 1500 mm more under trees compared with crop or pasture (Sudmeyer & Goodreid 2006).](image)

We now know that trees can create substantial soil water deficits as they access stored soil water during establishment (Figure 1). However, in the absence of fresh groundwater, the trees become increasingly dependent on rain falling directly on the area occupied by the lateral roots, with consequent reductions in water use and growth, and increasing tree/crop competition (Figure 2, Sudmeyer & Goodreid 2006, Sudmeyer & Simons 2008). This pattern of water use is reflected in long-term groundwater studies showing that while agroforestry plantings occupying less than 50% of the landscape can increase the depth to groundwater within the area planted, they generally have little off-site impact (Bennett & George 2008). Growing short rotation tree crops with conventional agriculture has been suggested as one method of exploiting stored soil water and reducing recharge. However, recent
investigations have shown that agricultural returns can be reduced for two to three years after the trees are harvested because of reduced plant-available water and nutrients.

Figure 2: Crop yield in the competition zone (CZ) of oil mallees, Eucalyptus spp. (expressed as a percentage of yield outside the CZ) for trees of various ages at 19 sites in the WA wheatbelt (Sudmeyer unpublished).

The shelter benefits of linear tree belts can be significant, but are often offset by crop losses alongside the belts where trees and agricultural plants compete for resources. Where wind erosion or sand blasting damage occurs, appropriately located windbreaks can improve agricultural productivity enough to offset the costs associated with establishment and tree/crop competition (Figure 3, Jones & Sudmeyer 2002). However, tree/crop competition can offset shelter benefits where wind damage does not occur regularly. In these situations the management of tree/crop competition either by severing lateral tree roots or thinning or coppicing the trees can significantly improve agricultural returns from windbreak and alley systems (Table 1). Note that all of these management options reduce tree water use, and with root pruning significantly reduces tree growth.

Figure 3: Mean crop yield in the lee of windbreaks relative to open conditions (20-30 H) in a dry year, one of average rainfall and with severe wind erosion. Data are averages for 70 field years in the WA wheatbelt. Distances from windbreak are expressed as multiples of tree height (H).

While some findings from this research may disappoint active proponents of agroforestry systems and general revegetation with trees, they do offer more realistic expectations of the
environmental and productivity benefits. Importantly they focus attention on the central problem of finding tree crops that are economically competitive with traditional agricultural enterprises. The importance of economics in the adoption of reforestation is well illustrated by the rapid development of the plantation forestry industry in WA. In the late 1980s DAFWA collaborated with the then Department of Conservation and Land Management (CALM) in researching the benefits of incorporating belts and blocks of blue gums (*Eucalyptus globulus*) into agricultural land.

The shared vision was for farmers to benefit directly from a new income source and improved agricultural productivity. Adoption was slow until the Australian Government set in place taxation legislation that actively encouraged plantation forestry primarily via private companies offering managed investment schemes (MIS). Unfortunately the vision for agroforestry was lost but within 15 years nearly 300,000 ha of hardwood plantations have been established in the higher rainfall areas of WA.

**Table 1: Increase in annual equivalent return (AER) from crops and pasture within the competition zone of trees with various management treatments. Values are for one side of tree line only (Sudmeyer & Flugge 2005).**

<table>
<thead>
<tr>
<th>Planting type</th>
<th>Increase (over control) in AER due to management of competition ($/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Root-pruned every 3 years</td>
</tr>
<tr>
<td>Windbreak</td>
<td>-14-193</td>
</tr>
<tr>
<td>Timber belt</td>
<td>-</td>
</tr>
<tr>
<td>Mallee hedge</td>
<td>13-79</td>
</tr>
</tbody>
</table>

In the medium and low rainfall areas maritime pine, sandalwood and oil mallees, are showing most economic promise and are in a similar situation to blue gums in the 1990s. The maritime pine project is driven by the Forest Products Commission (FPC), sandalwood plantings are managed by a mix of private individuals, FPC and investment companies with nearly 10,000 ha planted (Monica Durcan pers. comm.), and there are 12,000 ha of mallee plantings (John Bartle, DEC pers. comm.), primarily privately-owned but investment companies with interests in carbon sequestration are active in WA. Most plantings have been agroforestry systems with varying degrees of integration into conventional agriculture, only MIS sandalwood is taking the plantation forestry path. All systems are the subject of ongoing research into silviculture, productivity and environmental benefits and in each case public policy and monies are contributing significantly to adoption, either through subsidies and grants for expected environmental benefits or through tax breaks on establishment.

Projected climate change and the need for farming systems adapted to possibly drier conditions in marginal areas, and government policy, particularly as it relates to carbon sequestration and biofuels, will be central in providing the future direction for commercialisation and expansion of new and existing agroforestry systems. Given the current issues surrounding food security and the competing demands of land for fuel or food crops, it is important to find and develop viable agroforestry options that complement existing agricultural enterprises. The challenge for DAFWA and other research organisations is to be able to provide robust information about the productivity and environmental benefits of these systems to landowners and policy makers.
References


Assisting farmers adapting to salinity - integrating engineering and agronomy in the South West

John Paul Collins, Justin Hardy, Derk Bakker, Arjen Ryder and Bindi Isbister; john.collins@agric.wa.gov.au

Extending the lessons learnt from the Sustainable Grazing on Saline Lands (SGSL) project to the wider community has been the ongoing focus of the South West Catchments Council project “supporting farmers in adapting to salinity”. The community has embraced opportunities available through integrating engineering and agronomic approaches to reclaiming saline land. Early data collected on pasture and livestock production levels are helping to build the case for saltland pastures as a viable tool in increasing production from saline land and promoting the benefits to the wider farming community.

Plant-based options to profitably use salt-affected land are consistent with the NRM Objective “to minimise land degradation by encouraging development and adoption of salinity management practices which reduce the risk to the resource base while maximising social and economic returns”. Experiences from the SGSL producer network have built a solid case for saltland pastures in the farming system to enhance profitability and minimise further salinisation and will be extrapolated on within newly selected sites within the South West Catchments Council region (Collins et al. 2008).

Several sites have a grazing and livestock emphasis while others emphasise engineering and agronomy. That approach is governed by the need to improve the surface and subsurface drainage in areas of the Arthur River Shire that are both waterlogged and saline. In some instances the areas are severely degraded due to salinity while in others, salinity is not yet limiting productivity even though signs are emerging at the soil surface. In conjunction with the engineering measures, perennial grasses and shrubs will be introduced to improve the productivity of the more saline areas.

Seven sites were selected to trial the engineering requirements of severely degraded sites and the pasture and livestock production characteristics of salt tolerant pastures. Three are in the shire of West Arthur with an engineering and agronomic focus while the others are in the shires of Narrogin, Wagin, Dumbleyung and Woodanilling.

Engineering/agronomy focus – Shire of West Arthur

In keeping with the participatory approach used by SGSL, three sites were selected. The first at Duranillin has a range of surface water management options under investigation, including plough-built beds, cambered beds and mounds. At the second site in the Upper Catchment of Date Creek, slotted pipe subsurface drain will be installed on one side of a very sandy and severely degraded valley and on the other side in the ‘sand-clay-coffee-rock’ interface a closed-levy open excavator drain will be installed. The draw-down and flow in both systems will be compared. Tall wheatgrass will be planted between the drains. The third site is part of the Hillman Flats which is only moderately saline in some areas but severely waterlogged. A network of shallow surface drains will be installed to reduce the waterlogging, enabling return to a mixed pasture/cropping system which will be compared with a large tall wheatgrass planting on similar land and topography “across the fence” but without surface drains. To date, no site has been fully installed and the implementation of the drains is subject to the approval of the Commissioner.
Agronomic or livestock production focus

The remaining four sites rely wholly on plant-based options for increasing the pasture and livestock production. Based on lessons learnt from SGSL, appropriate combinations of surface water management, understorey species, and supplementation of feed and shotgun mixes will be used to demonstrate comparative treatments for enhancing profitability.

Site characterisation

**EM mapping**

Salinity across the seven sites was mapped using electromagnetic induction (EM38 and EM31). Salinity was highly variable, ranging from 20 to 970 mS/m in the horizontal dipole. Achieving pasture growth on soil with such variable surface salinity has been a challenge. A range of pastures will be required from lucerne, fescue and chicory on the fresher areas to tall wheatgrass on moderately saline areas, to saltbush (or a ‘do nothing’ scenario) on the severely salt-affected areas.

**Soil description, mapping and chemical analysis**

Soils across each of the seven sites were described using an auger survey and mapped based on the EM maps. Samples of each soil type were submitted to CSBP for analysis to determine the future nutrition requirements. EC1:5 values ranged from 5 to 430 mS/m in the topsoil confirming the variability in the EM maps. Gypsum was recommended on each site to improve soil structure. While this could improve pasture production through better soil structure, it was decided to delay this and focus on site improvement over the next two to four years through lowering the watertable.

**Hydrology**

Piezometers have been sited by a hydrologist and installed. On the Wilcox site (West Woodanilling) the water level varied from -1.1 to -1.66 m (Table 1).

**Table 1: Piezometer readings on Wilcox SWCC trial site (West Woodanilling)**

<table>
<thead>
<tr>
<th>Date</th>
<th>SWC00108 Level (m)</th>
<th>SWC00108 Salinity (mS/m)</th>
<th>SWC00208 pH</th>
<th>SWC00208 Level (m)</th>
<th>SWC00208 Salinity (mS/m)</th>
<th>SWC00308 pH</th>
<th>SWC00308 Level (m)</th>
<th>SWC00308 Salinity (mS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21/2/08</td>
<td>-1.57</td>
<td>-1.34</td>
<td>-1.22</td>
<td>16/4/08</td>
<td>-1.66</td>
<td>199</td>
<td>6.74</td>
<td>225</td>
</tr>
</tbody>
</table>

**Pasture production**

Pasture dry matter production ranged from 1.5 t DM/ha (saltbush and understorey) in Paddock 1 to 2 t DM/ha (saltbush and understorey in Paddock 2) and is shown in Tables 2 and 3. Soil salinity (EC1:5 and ECa) strongly determined the composition, with higher salinities generally corresponding to more barley grass and samphire in the sward. FOO levels in the understorey of Paddock 2 were double those in Paddock 1, consistent with low salinities. High variation in surface salinity also demonstrated inherent variability across the site.

Wavy leaf saltbush tended to be the dominant component in the shrub biomass, typically around 80% of the overall FOO (Table 3).
Table 2: Soil salinity/pH and pasture understorey FOO and composition

<table>
<thead>
<tr>
<th>Monitoring point</th>
<th>EC1:5 (mS/m)</th>
<th>ECa(H) (mS/m)</th>
<th>pHCa</th>
<th>FOO kg DM/ha</th>
<th>Common pasture composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddock 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1A</td>
<td>43</td>
<td>155</td>
<td>5.3</td>
<td>705</td>
<td>Barley grass, samphire, puccinellia, bare ground</td>
</tr>
<tr>
<td>1B</td>
<td>410</td>
<td>112</td>
<td>5.3</td>
<td>255</td>
<td>Barley grass, samphire, puccinellia, curly ryegrass</td>
</tr>
<tr>
<td>1C</td>
<td>97</td>
<td>118</td>
<td>5.0</td>
<td>599</td>
<td>Bare ground, barley grass, tall wheatgrass, samphire</td>
</tr>
<tr>
<td>1D (piezo)</td>
<td>1,674</td>
<td>227</td>
<td>5.5</td>
<td>437</td>
<td>Bare ground, barley grass, crassula, samphire</td>
</tr>
<tr>
<td>MEAN</td>
<td></td>
<td></td>
<td></td>
<td>499</td>
<td></td>
</tr>
<tr>
<td>Paddock 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2A</td>
<td>153</td>
<td>57</td>
<td>5.1</td>
<td>1,069</td>
<td>Tall wheatgrass, creeping saltbush, barley grass, samphire, silver grass</td>
</tr>
<tr>
<td>2B</td>
<td>9</td>
<td>37</td>
<td>6.2</td>
<td>804</td>
<td>As above</td>
</tr>
<tr>
<td>2C</td>
<td>2</td>
<td>9</td>
<td>5.2</td>
<td>1,214</td>
<td>As above, plus kikuyu, Gatton panic</td>
</tr>
<tr>
<td>MEAN</td>
<td></td>
<td></td>
<td></td>
<td>1,029</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Saltbush dry matter in Paddocks 1 and 2 at the Wilcox trial

<table>
<thead>
<tr>
<th>Site</th>
<th>Species</th>
<th>Stems/ha</th>
<th>Average g/shrub</th>
<th>Dry matter (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>River</td>
<td>239</td>
<td>663</td>
<td>159</td>
</tr>
<tr>
<td>1A</td>
<td>Wavy leaf</td>
<td>503</td>
<td>1,760</td>
<td>810</td>
</tr>
<tr>
<td>1A</td>
<td>Old man</td>
<td>156</td>
<td>515</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td></td>
<td>1,048</td>
</tr>
<tr>
<td>2B</td>
<td>River</td>
<td>275</td>
<td>377</td>
<td>104</td>
</tr>
<tr>
<td>2B</td>
<td>Wavy leaf</td>
<td>767</td>
<td>993</td>
<td>761</td>
</tr>
<tr>
<td>2B</td>
<td>Old man</td>
<td>301</td>
<td>593</td>
<td>178</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td></td>
<td>1,043</td>
</tr>
</tbody>
</table>

Livestock production

Saltland pastures supported liveweight changes from -95 to +314 g/hd/day on sites selected from the SGSL producer network (Thomas et al. 2008). It is anticipated that the complete set of livestock production data collected from the Wilcox site in West Woodanilling and Ward site in East Wagin will demonstrate maintenance of liveweight through to moderate gains in two to four-year-old wethers grazing the site. Early data from the Wilcox trial (Table 4) demonstrate that this is possible, however further data are required for validation.

Table 4: Initial liveweight and condition score (CS) data of sheep on the Wilcox trial

<table>
<thead>
<tr>
<th></th>
<th>24/3/08</th>
<th>7/4/08</th>
<th>21/4/08</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Mean weight (kg)</td>
<td>Mean CS</td>
<td>Mean weight (kg)</td>
</tr>
<tr>
<td>Control (Paddock 1)</td>
<td>43.9</td>
<td>2.4</td>
<td>47.5</td>
</tr>
<tr>
<td>Saltbush (Paddock 5)</td>
<td>43.7</td>
<td>2.3</td>
<td>45.9</td>
</tr>
</tbody>
</table>

All project and site data are stored for easy retrieval and analysis on the CRIS Farmbase.
References


Bioengineering actions of native plants on soil profiles in semi-arid ecosystems of the South West Botanical Province*

Bill Verboom; bill.verboom@agric.wa.gov.au

- Evidence that ‘tropical laterites’ are a Gondwanan phenomenon linked to evolution and phytogeography of certain plants
- Zoom into plan form variation of soil at ecosystem scales using the K, U and Th windows in radiometric imagery
- Use detailed observations across a myrtaceous/proteaceous ecotone and electron micrographs to understand variation at finer scales
- Look at survival strategies of proteaceous and myrtaceous woodland in relation to soil variation encountered

Evidence that plants and microbes use soil materials to build phytotaria.

- What modern evolutionary theory has to say about the reciprocal relations between plant speciation, phytotarium building and landform development
- Unequivocal evidence of bio-mineralisation in a contemporary setting

Bioengineering activities underpin soil forming processes across a variety of semi-arid ecosystems. These activities are spearheaded by principal deep-rooted tree and shrub species and their associated micro-organisms. Plants build phytotaria to modulate the form and distribution of key resources in their immediate environment. The term ‘phytotarium’ includes all biotic components and operational effects which plants and their associates exert on control and conservation of water and nutrients in an ecosystem.

Australian landscapes have been shaped by its unique biota. The phytotarium concept sheds light on the evolutionary history of SWBP and the world. The realisation that vegetation has contributed directly to radiometric signalling allows us to map original native vegetation in cleared areas

In relation to soils, natives may one day be employed to re-engineer our soils. I can envisage revegetation programs in which selected plant species are employed to:

1. improve the structure of duplex soils
2. improve the water and nutrient-holding properties of the sandplains
3. sequester carbon in the soil in inorganic forms.

Some examples of this process are illustrated in Figure 1.
Figure 1:

**A:** air-spaded exposure of a sector of the columnar pavement (CP) formed in lateral root catchment of a yate (Eucalyptus occidentalis). Parent tree (PT) is at far end of excavation;

**B:** close-up of columns showing fine bristle-like roots (arrowed), occasional polyp (P) and clefts (C) in rounded tops of columns. Larger roots of eucalypts and other species traverse the pit, some roots occluded for part of their length by column material;

**C:** fractured column (FC) showing bright red (ferrihydritic or haematitic) interior with fungal mycelium (M) exposed on interior surface. Lateral roots (R) of a cohabiting species (Conothamnus aureus) lie above, penetrate into or descend between columns;

**D:** site of nascent column formation in outlying region of lateral root catchment of E. decipiens showing reddish clay deposits surrounding major and associated fine roots of the eucalypt.
Merging biodiversity and production in the Southern Rangelands - Ecologically Sustainable Rangelands Management (ESRM)

Luke Bayley, Karen Roberts, Kaz Johnson and Richard Glover; luke.bayley@agric.wa.gov.au

The ESRM program started in September 2007 and builds on the Ecosystem Management Unit (EMU) project. The program is predominately NHT-funded with additional funding from DAFWA and DEC. It employs four staff, three based at Geraldton and one at Carnarvon, and is supported by a steering committee of pastoralists, Department of Environment and Conservation (DEC), Minerals Council of WA, DAFWA, DPI and the Rangelands Co-ordinating Group (RCG). The primary aim is to assist pastoralists and other rangeland managers to develop practices that promote healthy ecosystems and profitable and productive livestock operations. The program therefore ties in closely with other DAFWA and DEC programs such as DAFWA’s Food on Offer project and DEC’s off-reserve conservation initiative. ESRM supports the growth of sustainable pastoralism (in the regions we are working) and believes biodiversity can and must be improved through improved livestock and total grazing management.

What does ESRM do?

A key part of the process involves pastoralists and rangeland managers undertaking a station overlay exercise. This marks key features of the property onto overlays placed on aerial and land system maps. The features include their most and least productive land types, infrastructure such as yards, fences, bores and watering points, problem areas, those under pressure from feral animals and of high ecological importance. These maps allow the pastoralists to make connections between issues, their causes and solutions.

These overlays and the associated discussions are then used to develop a property action plan for the station that supports solutions for the key issues as identified in the mapping process. This action plan may support new management initiatives, funding applications for
on-ground works, assisting in focusing work activities or be developed to concentrate on one particular land system. Each station responds differently to the planning activities with different entry points and therefore the process is flexible to accommodate different needs. Not all can respond to landscape ecology assessments - for some it’s not practical or the most productive place to focus implementation activities. Many stations would be well served with support to further develop grazing systems, assessing feed on offer, feed budgeting, monitoring and review of existing enterprise arrangements, pursuing infrastructure upgrades and further business planning. Others will benefit from immediate actions to reclaim perched floodplains, improve biodiversity, reduce run-off or invest in other restorative activities. ESRM has some funding available and an appropriate system for investing these funds for maximum benefit to the catchment is being developed.

Narrowing the focus

ESRM’s brief is to cover the entire Southern Rangelands, however this is not achievable with current staffing levels. To be most effective it needs to work with established and effective community/industry groups and also focus planning and on-ground initiatives within landscape catchment boundaries. As a result, ESRM has engaged with a very keen and active group in the north. The Upper Gascoyne, Lyndon and Wooramel LCDC groups have put together a steering committee and are working in partnership with ESRM. It is anticipated ESRM will continue to move north over the coming years.

The Southern Rangelands has been facing gradual decline in productivity and viability. However there is evidence that rangeland condition has been improving on some pastoral leases over the past 15 years. The main driver of landscape function results from management over the last 100 years, particularly excessive stocking rates at key points in history, mainly the 1900s and the 1940s. This has placed the system into a downward cycle where initial groundcover loss causes water loss, then soil loss, then more plant loss followed by the disappearance of critical plants, animals and insects that are important for landscape function and livestock production. The system loses resilience and cannot recover or respond to events such as cyclones and droughts or grazing resulting in declining productivity. ESRM’s role is to help identify trigger points for this cycle and provide some effective solutions and assistance for implementation.

The planning process is critical. This allows us to identify areas of opportunity and concern. Solutions and support is varied, some examples include:

- Technical and social support to undertake new management practices and improve decision-making
- Upgrading fences and yards to gain control of livestock so that numbers and grazing pressure can be controlled
- Improved access to information and monitoring of new practices
- Relocating, shutting or opening new watering points may redirect grazing pressure to less sensitive areas, rest areas or reduce overall grazing pressure
- Matching numbers of stock and other mouths to the amount of feed available so that plants can survive, reproduce and perform their roles in the system
- Revegetating appropriate areas
- Feed budgeting and determining stock flows
- Support for industry leaders
- Ponding banks and other earthworks to slow water, encouraging it to unload soil, spread out, rehydrating the landscape
- Walls and bunds in the waterways and rivers to slow water.
It is very important that these actions are not implemented in isolation - most solutions require a number of actions to be effective and all require on-going support. In addition, the removal of stock is not going to be a complete answer in many cases - the system may have tipped too far to stabilise itself in a productive manner and physical intervention is needed. This is where ESRM is important in helping pastoralists to look at the big picture and prioritise activities that maximise landscape function and hence productivity.

The future

A variety of tools is needed to turn the ESRM planning process into a valuable product for land managers, the rangelands and investors. It is essential to develop a holistic program that supports industry development, market-based incentives, rigorous self-assessment and reporting procedures and coordination between the public and private sector. Once these tools are embedded in the program, with appropriate planning and consultation it will be effective in another region.

In remote and poorly serviced regions it is advantageous to develop programs that can guarantee governance arrangements, build local and regional leadership and decision-making capacity and have capacity to access and implement world’s best practice. This would improve our ability to serve our clients and partners, seek funds, attract and retain staff and improve the condition and productive capacity of rangeland environments.

The scale of investment must stimulate the development of a model that is robust, supported by industry and stakeholders and propels future rangeland/pastoral NRM initiatives. There are too many examples of projects starting, delivering, finishing and then completely disappearing. All their momentum and experience is lost – we cannot afford this to continue.

We cannot afford to lose project momentum in the rangelands of WA or miss this opportunity through ESRM to significantly shift the short-term, uncoordinated and unsustainable approach currently being displayed in rangeland extension. It appears that unless significant movement is made in the next 5–10 years the few opportunities that exist now to improve the condition of the rangelands and the viability of rural businesses could be largely compromised by serious land degradation and rural social decline that extends beyond our ability to manage.
Resource condition monitoring and analysis of long-term groundwater trends

RJ George, GP Raper, DL Bennett, C Fairclough, RJ Speed, A Kendle, B Gibbons, JA Simons, B Donald, RH Smith, N Wilkins, G Stainer, R Ferdowsian, A Ryder, I Rose, D Michael, T Mathwin, J Kowald, M Smith & R Wheater; richard.george@agric.wa.gov.au

Consecutive Western Australian Governments have fostered agricultural development in the ‘wheatbelt’. By 2001 over 19 million hectares of land was cleared of perennials and annual crops and pastures established.

In 1950 a survey of farmers revealed that 40,000 ha of previously arable land had become salt affected, and over 400,000 ha were at risk (George 1990). Since then the extent of salinity has been tracked using a combination of methods, at a range of scales. Extensive surveys of salinity were undertaken by the Australian Bureau of Statistics and Department of Agriculture, every five years over a 47-year period. While the questions asked have varied slightly, farmers report the area saline has increased from 73,476 ha (1955) to 932,695 ha (2003).

Between 1996 and 2000, the Land Monitor project used satellites and a high resolution digital elevation model (±1 m) to estimate salinity at paddock-scales. Interpretation showed that 992,000 ha of the wheatbelt, including 821,000 ha of agricultural land, were severely salt-affected. An additional area was classified saline (85,700 ha) within palaeodrainages (336,580 ha). The project also estimated the equilibrium valley hazard (not risk) using a digital elevation model and rule-based approach. This was forecast to be between 2.8 and 4.4 M ha.

This short paper reviews analyses of the SALTWATCH database. It also reports on progress towards completion of the RCM Gaps project – a program of drilling and monitoring to enable gaps in SALTWATCH database to be filled and enable complete analysis in the future.

Watertable analysis

Rotary air-blast drilling rigs, operated by regional hydrologists were used to establish a network of 1,318 long-term monitoring bores [termed SALTWATCH bores]. These bores are in clusters at about 100 catchments/sites across the agricultural regions representing most of the 19 Mha cleared area. Bores were typically drilled to basement, on transects from upper to lower slopes, or in areas that were saline or were suspected of having a significant risk.

Manual time series analyses of trends in all bores were undertaken (<1990, 1990-2000, 2000-, and all periods) and presented for two periods (Table 1). Analysis of each period was conducted by calculating the dominant trend. Linear trends were simple to assess, however if there was significant seasonal variability, trends were derived from a line of best fit connecting summer minima. These results are compared to annual rainfall pre- and post-2000 (Figure 1).

Bores qualified for analysis if they were in cleared agricultural land, remote from effects of salinity management treatment (drains, trees, perennial pastures) and met minimum standards (e.g. five years duration and/or 20 monitoring observations). The average catchment had 14 bores and 50 observations. Trend analyses were conducted between 266 and 1,318 bores [<1990 (n=266), 1990-2000 (n=990), 2000-2007 (n=1,198), and ALL (n=1,318)].

Results

The relative proportions of bores with rising trends changed after 2000, in terms of amount and degree of rise/fall, and also spatially (Table 1). Prior to 2000, in four regions 53-74% of all bores had rising trends and <6% had a falling trend. About 9-47% had no trend (stable).
Pre-2000, the western South Coast had the greatest number of falling trends (13 bores or 17%) and fewest stable trends (9%). After 2000, the number of bores with rising trends decreased in four of the five regions. This was most pronounced in the Northern Region (down to 18%), and progressively reduced towards the eastern South Coast where the pre- and post-2000 number was unchanged (71-72%).

Table 1: Bores analysed for groundwater trends 1990-2000 (n=990) & post-2000 (n=1,318 bores)

<table>
<thead>
<tr>
<th>Region</th>
<th>Bores</th>
<th>Pre-2000 (%)</th>
<th>Post-2000 (%)</th>
</tr>
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<tr>
<td></td>
<td></td>
<td>Rising</td>
<td>Falling</td>
</tr>
<tr>
<td>Northern</td>
<td>109-170</td>
<td>66</td>
<td>6</td>
</tr>
<tr>
<td>Central</td>
<td>299-479</td>
<td>47</td>
<td>5</td>
</tr>
<tr>
<td>South-West</td>
<td>331-370</td>
<td>53</td>
<td>3</td>
</tr>
<tr>
<td>South Coast (western)</td>
<td>76-80</td>
<td>74</td>
<td>17</td>
</tr>
<tr>
<td>South Coast (eastern)</td>
<td>175-219</td>
<td>72</td>
<td>5</td>
</tr>
</tbody>
</table>

Groundwater trends differ depending on depth to watertable. Plots of trend by depth for each period (<1990, 1990-2000, all time) for the five regions (Figure 2) show that prior to 2000 (a plots), nearly all bores displayed a rising or stable trend whether the watertable was shallow or deep. However, after 2000 (b plots) the trend appeared to depend on depth to watertable. In the Northern Region, downward trends to -0.5 m/yr are now common in bores with shallow watertables (<10 m); lower rates of fall (-0.2 m/yr) were apparent for deeper watertables (>20 m). In the Central Region, rates of fall were less (-0.2 m/yr) and only two were observed where watertables were >10 m. In the South West and western South Coast the magnitude of falls was lower again (<-0.1 m/yr), and only observed at <5 m watertable depths. By contrast, in the eastern South Coast, the trends remained the same pre- and post-2000: upwards (>0.2 m/yr) or stable.

The magnitude of long-term groundwater rise also differs from north to south (Figure 2c). In some Northern Region bores, rises in the 1990s have been offset by falls after 2000. However, this wasn’t the case in the entire Northern Region (e.g. not all Perth Basin), nor in other regions, where watertables show a strong net rise (<1990-2007). In the Central Region, South West and western South Coast, it was usually only ‘discharge’ bores that demonstrated falling trends (<-0.2 m/yr; post-2000 flood). Most bores in areas of hazard, uplands or those remote from discharge zones, continue to rise.

After 1975, South West annual rainfall reduced relative to the pre-1975 average. Since 2000 in the north and west, rainfall has further reduced (Figure 1). By contrast, it has increased in some areas, such as the south-east (Esperance) and slightly in the central region, due to three large flood events. Cumulative reductions in some areas exceed 40%.

Discussion

We attribute the observed groundwater responses to interaction between three factors: clearing, reduced rainfall, and onset of hydrologic equilibrium. Experimental data implicate clearing as the dominant causal factor in groundwater rise and the expansion of land salinity (Peck & Williamson 1989). The analyses presented here allow some insight into the impact of the other two factors.

Rates of groundwater rise observed from 1975 to 2000 were significant and occurred over a period when the area of saline land grew from 167,000 to 1 million hectares. We attribute this rise primarily to land use change brought about by the scale of clearing which preceded it.
Notably, this 25-year period had reduced rainfall relative to the previous 50 years in all areas except the central South Coast.

![Map showing change in annual rainfall](image)

**Figure 1: Change in rainfall from long-term average (pre-1975) to 2000 (left) and 2007 (right)**

Since 2000, the numbers of bores with rising trends and their rates of rise have decreased. However, this response varies spatially, with most reductions in the Northern Agricultural Region, and none in the eastern South Coast. Persistent drought and high evaporative demand in the Northern Agricultural Region (>20% rainfall reduction) appears to have negated previous watertable rise. By contrast, in much of the Central, SW and western South Coast, changed rainfall has not caused the same degree of reduction. Notably, in the South West, the post-2000 reduction has not caused obvious change, while on eastern South Coast, where rainfall has increased, trends remain upward.

Rates of groundwater rise are affected by the degree to which the catchment has responded to clearing. In catchments still actively filling [not near equilibrium], reduced rainfall-recharge appears to have had no discernible impact on rising trends. As these catchments approach equilibrium and discharge areas grow, climate impacts will become the dominant controller of trends. As noted, the dataset has not been analysed by landscape position, thus we have over-represented some landscapes and some with little or no data. A drilling program underway will fill those gaps.

Despite lower than average rainfall over much of the wheatbelt since 2000, we continue to see salinisation expand in most regions, especially following episodic floods, such as occurred in 1999-2000, 2001 and 2006. Hence our measured reductions of watertables in some wheatbelt valleys may be as much attributed to recessions between these floods, as to a shift in mean annual rainfall.

The recent change in groundwater trends may have a significant implication for assessing the likely future extent of salinity and the effect of management, especially those established as a result of the National Action Plan for Salinity and Water Quality. They will also have an implication on policy. We conclude that monitoring remains a foundation activity of any new NRM program and a priority for the future.

**References**


Wood WE (1924) Increase of salt in soil and streams following the destruction of native vegetation. *Journal of the Royal Society of Western Australia* 10(7): 35-47.

**Figure 2:** Hydrograph derived trend analysis (+ Rise /- Fall) by depth to groundwater (2005-2007) for all bores in Agricultural Regions (1=Northern, 2=Central, 3=South West, 4=South Coast-west and 5=South Coast-east) for periods (a) <2000, (b) 2000-2007 and (c) All records (>1975-2007)
Supporting adoption of perennial pastures in the south west low to medium rainfall zone

*Ned Crossley* and *Kathi McDonald; ned.crossley@agric.wa.gov.au*

Significant resources have been allocated through regional NRM investment plans to research and extension to increase the perennial pasture component of farming systems to increase water use to manage recharge, stream and dryland salinity. Despite a significant increase in extension effort throughout the south west from DAFWA and other groups such as Saltland Pastures Association, Evergreen Farming, WA Lucerne Growers and the Future Farm Industries CRC (previously CRC for Plant-based Management of Dryland Salinity), the area of perennial pasture grown is small in relation to that potentially suitable.

Our project set out to establish the reasons for the low adoption of perennials and then develop an effective adoption plan that will encourage their wider use.

This contributes to the NRM divisional outcome of *profitable and sustainable agricultural systems which are matched to the capability of the natural resource base and minimise off-site impacts*. It also aligns well with the objective to *minimise land degradation by encouraging development and adoption of management practices which reduce the risk to the natural resource base*. The project fits within the priority objective of *Sustainability Integration - moving toward more sustainable land-use systems (where use is matched to land capability)*.

The two year project is funded by SWCC, ending in December 2008. We have partnered with Evergreen Farming and other DAFWA projects for extension opportunities and to identify growers with an interest in perennial pastures who were able to contribute to information about barriers or drivers to adoption or to developing best management practice.

The possibility exists to develop partnerships with local groups in the development and implementation adoption plans in the last phase. The idea of forming such partnerships to solve outstanding problems with perennials and develop reliable management practices supported by farm-scale demonstrations was suggested at some focus groups, however additional resources and personnel will be required to support these partnerships beyond the life of the current project.

The project has four main areas of activity:

1. Socio-economic enquiry to identify drivers and barriers for the adoption of perennial pastures
2. Development of best practice guidelines for establishment and management of perennial pastures
3. A demonstration component
4. An adoption plan that addresses barriers and drivers identified.

The project employs *Ned Crossley (0.8 FTE)* overseeing the investigation of drivers and barriers and development of the adoption plan, and *Kathi McDonald (0.6 FTE)* overseeing development of best practice guidelines and the demonstrations.

The enquiry took the form of semi-structured interviews and focus groups to gain insight into many issues that influence growers to trial and adopt perennials or not. The information gathered has also helped identify target groups we can work with to develop pasture systems that incorporate more perennials.
Best Management Practice guidelines (BMPs) are being developed to help trial and adopt perennials with greater confidence. Experienced growers have provided information. The guidelines will be produced for land management units (LMUs) best suited to growing perennials and relevant enterprise types identified in interviews and focus groups.

Three demonstration sites were established for use in field days. A mix of lucerne, fescue and chicory was established at a site at Katanning and two sites in the Williams Shire.

What we found

Much of what we learned is not new. Generally, growers expressed a much more conservative view of the potential of perennial pastures than researchers and extension professionals. Barriers and drivers to adoption are a mix of personal, social, economic and technical factors that translate into willingness and ability to adopt.

Personal factors including acknowledging a need or desire to change, social and economic situation, attitude to learning and perception about riskiness and complexity, influence a grower’s ability and willingness to adopt perennials.

Social networks are effective at reporting outcomes of farm trials – it seems everyone knows someone who has tried perennials and failed - and while they can be useful forums for exchanging ideas and learning about new practices they also very effective mechanisms to maintain conventional practice. High establishment costs (including the opportunity cost of forgone production and seed) and the need for additional labour in a tight market were compelling barriers to adoption. On the other hand the value of extra out of season feed was an appreciable driver. Economic uncertainties about the future of the Merino wool industry are also constraining many from investing in pasture development of any kind.

Technical factors such as access to credible agronomic knowledge and establishment and management prescriptions, availability of seed, and access to machinery, represent significant barriers to adoption. The type of grazing system has a strong influence on persistence of pastures, e.g. perennials flourish under rotational grazing so practitioners of these systems are more likely to adopt them.

A number of opportunities to help foster greater level of adoption were identified:

- agronomy packages suited to their area
- local trials and demonstrations
- access to working farm-scale perennial grazing systems
- access to experienced growers and working examples
- support for group learning initiatives to interest, inform, involve and inspire growers to learn about, trial and adopt appropriate perennial grazing systems (Hussey et al. 2008).

Conventional extension methods have not led to a greater adoption of perennial pasture systems. This is due to difficulties of complexity, trialability, and riskiness and uncertainty due to a lack of confidence in the future for sheep grazing enterprises.

Understanding the barriers and drivers to adoption is essential in order to increase adoption of any (perceived) complex system. This understanding provides a sound platform from which to begin working with individual growers and groups to resolve the issues to develop workable systems. Agronomy packages supported by demonstrations and working examples will help inform growers to help them handle the complexity and be inspired and confident to trial these systems.
References


Hussey BMJ, Baxter A (2008) Love it or lose it: why it is important that landholders care about the future of their remnant vegetation. State NRM Conference, Blackwood Basin Group, Boyup Brook, WA.
Planning for impact in catchments: Beyond incentives to technology development

John Blake, Ruhi Ferdowsian, Tim Overheu and John Simons;
john.blake@agric.wa.gov.au

The purpose of the project is to enable better return on investment in managing risk to priority natural resource assets. This involves determining what practice changes should be targeted in key catchments. It is recognised that the targeting achieved in 2004-05 can be improved for phase 2 (2009-14). The team engaged a project review process and participated in Planning for Impact workshops. Shared objectives on resource use efficiency are being developed within the industry.

This paper reviews the processes used in determining priorities for NRM investment in the South Coast region in 2004-05 (Krost *et al.* 2007). It also examines the likely modes of investment in South Coast region land systems after 2008 based on an asset focus (localised and dispersed). This review has been supported by the SIF3 research (Salinity Investment Framework 3 study by Pannell *et al.* 2008) currently in progress. The South Coast NRM decision in February 2008 was to move from examining only salinity investment priorities to an NRM Investment framework for the region. This will involve using the proposed South Coast Risk analysis framework (STRATAGEM, Simons *et al.* 2007) and proposed tools such as INFFER (Investment Framework for Environmental Resources).

This project particularly addresses two priority directions of the NRM Division. These are 'Influencing NRM Regional Council investment' and 'Catchment-scale water management for containing NRM risks'. The South Coast has relatively short rivers with rejuvenated drainage. This is very different to much of the agricultural areas which are dominated by ancient drainage and regional groundwater systems. The purpose of public NRM investment is to protect the priority localised NRM assets by bringing these agro-ecosystems into improved balance. Water balances with improved nutrient, salt, soil, carbon, energy and biodiversity balances all contribute to improved condition of the assets (localised and dispersed) in these ecosystems. Salinity, sedimentation, nutrient eutrophication (plus other chemical contamination including acidification) and inundation are key risks associated with the altered hydrology of the region’s agro-ecosystems.

During 2004-05, the technical assessment based on priority assets and level of threat to that asset (SIF approach) was used as a basis for consultation with land managers and communities to determine values. A multi-criteria analysis of NRM options was undertaken (Petersen *et al.* 2005) with the six subregional NRM groups. A capacity for change decision matrix was developed (Overheu *et al.* 2004) and strategic catchments were proposed (Figure 1). Further technical assessment and community consultation in 2005 resulted in the selection of priority subcatchments for the initial 2005-08 investment.

Table 1 shows the NRM risks associated with major natural resource assets in the region.
Figure 1: Location of the eight strategic subcatchments 1: Upper Frankland-Gordon; 2: Upper Hay; 3: Oyster Harbour; 4: Middle Pallinup; 5: Bremer River; 6: West River; 7: Young River; 8: Lake Warden

Table 1: Environmental risks associated with major natural resource assets in the region

<table>
<thead>
<tr>
<th>ASSET - high value localised</th>
<th>Feature &amp; Values</th>
<th>Salinisation</th>
<th>Nutrient eutrophication</th>
<th>Sedimentation</th>
<th>Inundation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Warden Wetlands</td>
<td>RAMSAR wetlands</td>
<td></td>
<td></td>
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<tr>
<td>Wilson Inlet &amp; river catchments</td>
<td>National Recovery Catchment</td>
<td></td>
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<tr>
<td>Stokes Inlet: Lort &amp; Young Rivers</td>
<td>Corridor priority</td>
<td></td>
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<tr>
<td>Lake Gore &amp; Dalyup catchment</td>
<td>RAMSAR wetlands</td>
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<tr>
<td>Fitzgerald River: Central South Coast</td>
<td>Fitzgerald Biosphere</td>
<td></td>
<td></td>
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<tr>
<td>Cranbrook &amp; Tambellup town environs</td>
<td>Rural Community: Infrastructure</td>
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<tr>
<td>Wellstead Estuary – Bremer River</td>
<td>Fitzgerald Biosphere</td>
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<tr>
<td>Oyster Harbour - Lower Kalgan River</td>
<td>State &amp; Community Asset</td>
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<td>Lake Magenta Reserve</td>
<td>State biodiversity asset</td>
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<tr>
<td>Lake Balicup reserve</td>
<td>State biodiversity asset</td>
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<tr>
<td>Pallinup River Catchment (dispersed)</td>
<td>Rural community asset, high cultural value</td>
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<tr>
<td>Pink Lake</td>
<td>Tourist attraction</td>
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</tbody>
</table>

Key

- **High**
- **Medium**
- **Low**
The initial SIF3 analysis (on salinity risk only) identified five areas – Lake Warden, Lake Gore, Pink Lake, Balicup nature reserve and Magenta Lake reserve with Lake Warden as the standout priority (Massenbauer 2005). These were mostly based on an engineering option for a capital works program however studies indicate this option is not viable except for the RAMSAR wetlands. Capacity for change is the other identified limitation. The Catchment Demonstration Initiative (Fitzgerald Catchment, Daniel 2005) is an example of a priority project which on initial SIF3 analysis would be a target for technology development rather than incentives.

STRATAGEM is a proposed whole of landscape risk analysis (multi-risk and multi-theme). It involves a three-dimensional matrix to consider various impacts:

- On-site impacts
- Off-site impacts
- Non-biophysical aspects
- The positive and negative impacts of proposed management actions.

The method considers seven types of threats for each asset and includes evaluating the influence of different actions. The seven types incorporate the degree of threat to:

- Agriculture (ordered in relation to spatial extent and timing)
- Transport networks
- Urban infrastructure
- Biodiversity
- Waterways and wetlands
- Estuaries
- Social capital/well-being (economic, health and social issues) of communities.

The SIF3 process has highlighted gaps in the science and a need for investigations in some of the current priority areas. The current investment allocations need to be adapted (Table 2) for phase 2, as not all strategic catchments have discrete localised high value assets but some were selected more for their dispersed assets. The catchment groups as co-investors have set their own landscape specific targets which align with the Land Theme targets developed by DAFWA specialists. The key South Coast groups engaged in catchment management are the Lake Warden and Young River Catchment Groups, Oyster Harbour Catchment Group, the Bremer River Catchment and Fitzgerald River Catchment Groups, Wilson Inlet Catchment Committee and Pallinup River Catchment Group. Consultation with them is already enabling stronger focus (e.g. the Bremer Catchment Management Group is developing a ‘hotspot focus’ in consultation with DAFWA specialists).
The suggested models are for discussion only but highlight options beyond incentives and indicate a major role for DAFWA as an R&D (technology development) organisation.

### Conclusions and future actions

The lessons learnt for future investment allocation:

- Many catchment communities achieved excellent consultation, and in many catchments strong science was applied to guide investment. Only where both were achieved together was excellent progress made.

- Theme Integration: Time constraints in 2005 meant integration between the themes was limited. Whole of landscape risk analysis for the catchments' assets is needed to drive theme integration (Simons J.).

- The current investment allocations need to be adapted (refer Table 2) for phase two as not all Strategic catchments have discrete localised high value assets but some were selected more for their dispersed high value NRM assets.

- The Adaptive Management approach requires ongoing Investment in participative R&D (technology development) which has been shown to be the most cost effective in SIF3 and Healthy Catchments results. The SIF3 process certainly indicates a major role for DAFWA as an R&D organisation. The next phase needs increased emphasis on this role, as funding is now longer term without the 2005 scenario of a three-year investment only.

- Timeframes: to get priority landscapes into improved balance requires phases of investigation and phases of implementation. Investment cycles need to be >3 years.

- For protection of high value, non-agricultural terrestrial assets (infrastructure and biodiversity), the role for incentives is limited by the likely funding available. Engineering (subject to economic analysis) may be appropriate when the value of the asset and the urgency for action are high.
  - Plant-based R&D is relevant particularly where the asset value is high but the urgency is low. It is justified on the basis of reducing the public cost per hectare of treatment. Where current plant-based options are not sufficiently profitable, R&D to develop improved options (technology development with farmer groups) should continue to be a key investment.
  - In transition to the *Caring for our Country* program a key focus is proposed as *Sustainable farm practices for water quality* in the priority landscapes. This addresses two key areas in the program and is being applied by the regional NRM group.

The working groups in collaboration with the SIF3 research team are working to extend the NRM Investment framework beyond salinity into water quality, biodiversity, and pest plants.
and animals. There is need to develop improved methods to simultaneously consider multiple threats and compare priorities across asset classes. This was suggested in the STRATAGEM proposal (Ferdowsian et al. 2007) and in the proposed modified framework the SIF3 team has called INFFER3.

Acknowledgments: Southern Ag farmers, South Coast NRM, NHT2/NAP, NLP and the farmer groups, DAFWA and contributing agencies, and the subregional NRM groups in particular.

References
Petersen EH (2005) Multi-criteria analysis of sustainable land management priorities for the South Coast of WA. CRC for Plant-based Management of Salinity and Department of Agriculture.

3 INFFER (Investment Framework for Environmental Resources) is a new asset-based approach to natural resource management proposed by David Pannell and Anna Ridley. The core aim is to help investors to achieve the highest value outcomes possible with available resources. It covers environmental threats such as water quality decline, salinity, biodiversity decline and pest plant and animals for the best public outcome. A core component of INFFER is the Public benefits: Private benefits Framework, which helps identify which policy tool, if any, should be used, depending on the levels of public net benefits and private net benefits resulting from actions undertaken (not limited to salinity).
The role of land resource information in achieving sustainable land use*

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This presentation will examine the role of land resource information in achieving sustainable land use goals.

Providing good information which logically should inform, influence and improve land resource management on its own rarely leads to better management of the land. A series of steps or processes can encourage land managers to undertake more sustainable management practices.

The steps in this process, from identifying the issues to influencing the people on the ground will be examined and the NRM role analysed. Although primarily with a land resource information focus, this process has relevance to activities across the whole NRM Division. The process will be illustrated with examples (both good and bad) from WA, Australia and overseas, and will coordinate with other land resource assessment presentations to provide a logical sequence to how NRM can influence land management.
Mission impossible: ‘precision pastoralism’ for sustainable profits

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‘Precision pastoralism’ offers great benefits to profits and sustainability but implementation demands a mindset shift for both DAFWA and industry. DAFWA has changed its mindset and progress from industry is encouraging despite recent challenges from drought. Self-mustering yards (SMY) on waters enable the first step, namely controlling grazing pressure to stay within seasonal fodder supply. Participatory extension projects are addressing this challenge in the southern rangelands.

A body of research supports seasonal control of total grazing pressure:

1. Overgrazing causing death of groundcover plants results in accelerated runoff, soil erosion and dessicated landscapes (Pringle & Tinley 2003)

2. Loss of perennial grasses and other groundcover species reduces infiltration rates and accelerates soil erosion

3. The herbage of many shrubs does not meet the metabolisable energy (ME) requirements of lactating or growing livestock but it can provide abundant dietary nitrogen

4. In semi-arid mulga woodlands, native perennial C3 grasses producing a mere 100 kg/ha/year of green leaf can meet these ME requirements but often die when overgrazed (Freudenberger et al. 1999)

Brennan et al. (2005) proposed that ruminants in the WA shrublands readily satisfy their dietary nitrogen requirements but often face limited supplies of ME. As a result, perennial grasses and other perennials high in ME are preferentially grazed to the extent that they only survive under shrubs or branches where they are protected from continuous grazing. Rigorous seasonal adjustment to grazing pressure is thus necessary to enable species providing high ME herbage to regenerate and provide the groundcover which improves rainfall infiltration and controls soil erosion. Simple low-cost SMY technologies enable managers to achieve this requirement.

On-station workshops at the start and end of a production year provide training in the management skills required for tight control of total grazing pressure. A case study approach is used for the workshops and a continuous improvement model targets individual producers’ land, livestock and profit objectives. Participants are offered follow-up support to plan and monitor performance over a production year for their nominated management unit. Phone conferences provide a cheap means to discuss issues, provide peer and professional support and maintain project momentum. Funding has come from consolidated funds (CF), NLP, FarmBis and producers’ workshop fees. With staff support, the Lyndon LCDC won NLP funding to complement these workshops with the services of a respected ruminant nutritionist.

The project team produced a ‘glovebox guide’ to assist producers in the field which is now ready for publication.

A few pastoralists enthusiastically support this paradigm shift in management and increasing numbers are volunteering management units as case studies to engage the support of our Southern Rangelands Extension Team.
As confidence builds and rangeland regeneration accelerates, additional precision practices can be introduced. These may include short mating periods with fewer sires, pregnancy testing, strategic supplementation, weaning and timely marketing.

References


Groundwater responds by declining in a drier climate in the Northern Agricultural Region

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A groundwater monitoring network has been progressively installed throughout the Northern Agricultural Region (NAR) since 1990. Its purpose is to measure rates of groundwater rise and assess the timing and impact of dryland salinity.

Reduced rainfall and particularly dry conditions have persisted in the NAR since 2000. This paper reports on the impact of the prolonged drier period on trends observed in throughout our groundwater surveillance network.

Site description

The NAR covers about 6 million hectares. Overall, more than 75% has been cleared for dryland agriculture however in the eastern and northern parts more than 90% of the native vegetation has been removed. Extensive clearing was completed prior to 1990.

Average annual rainfall ranges from about 700 mm in the south-west to less than 250 mm in the north-east. Throughout, 1999 was a very wet year. However, since 2000 particularly dry conditions have prevailed and of the last eight growing seasons, average rainfall only occurred in 2005.

There are three distinctly contrasting geological areas. In the east the Yilgarn Craton underlies about 3 million hectares. The Yilgarn Craton is predominantly Archaean granitoid basement. Groundwater occurs within a gritty clay saprolite profile weathered in situ.

In the west, the Perth Basin contains thousands of metres of Mesozoic sediments underlying about 2.5 Mha. Significant and regional aquifers containing vast resources of good quality water are present in the Yarragadee and overlying Parmelia Formations.

In the north, the Northampton Block is an inlier of Proterozoic gneissic basement underlying about 0.5 Mha. It is partially capped by thin sequences of Jurassic sediments forming characteristic flat-topped hills with steep breakaway slopes and incised drainage lines.

Methodology

Groundwater levels have been manually monitored at about five week intervals. The data were plotted and a line of best fit drawn manually on the hydrographs to calculate trends.

In most data there was a clear distinction between pre-2000 and post-2000 trends. For example, Figure 1 shows data from two sites on the Northampton Block. In the longer dataset, there was no trend determined for CV2D pre-2000 and a declining trend of 0.25 m/yr post-2000. In the shorter dataset, no trend was determined for CVG14D pre-2000 because of insufficient data and an average declining trend of 0.17 m/yr was determined post-2000 although (as for CV2D) the rate of decline far exceeded this between 2000 and 2003.

In the low rainfall east groundwater recharge is typically episodic. Figure 2 shows groundwater hydrographs for two sites. The deeper watertable at site OM100B exhibits episodic recharge in 1996, 1998 and 1999 for which an overall average rising trend of 0.27 m/yr was determined. The shallow watertable at site OM50B exhibits seasonal fluctuations typical of saline valley floor discharge areas pre-2000. Post 2000 the declining trend at site OM50B tapers with the average rate of decline determined to be 0.26 m/yr.
In sedimentary profiles seasonal fluctuations of groundwater are typically muted, for example as in Figure 3 which shows the groundwater hydrograph for a piezometer (LS21A) screened in the Yarragadee Formation of the Perth Basin. This example clearly shows the episodic rise caused by the very wet year in 1999 that is present in all of the data. In determining trends the episodic jump was generally ignored and as in this example the pre-2000 trend determined did not include the rapid rise that took place in the latter part of 1999.

Results

Results of the groundwater trend analysis for the NAR are summarised in Table 1 and presented in Figure 4 where groundwater trend in m/yr is plotted against current groundwater depth in metres for pre-2000 (left) and post-2000 (right).
Table 1. Results of groundwater trend analysis pre- and post-2000

<table>
<thead>
<tr>
<th>BORE NUMBERS</th>
<th>Pre-2000</th>
<th>Post-2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>110 (100%)</td>
<td>171 (100%)</td>
</tr>
<tr>
<td>Rising trend</td>
<td>73 (66%)</td>
<td>31 (18%)</td>
</tr>
<tr>
<td>Falling trend</td>
<td>7 (6%)</td>
<td>118 (69%)</td>
</tr>
<tr>
<td>No trend</td>
<td>30 (27%)</td>
<td>22 (13%)</td>
</tr>
</tbody>
</table>

Figure 4. Groundwater trend plotted against current depth pre-2000 (left) and post-2000 (right)

Prior to 2000 groundwater levels were generally observed to be rising or at equilibrium. Since 2000, drier climatic conditions have prevailed and groundwater levels are now observed to be predominantly declining. Declining groundwater trends are observed irrespective of geology, depth to groundwater or land management.

Discussion

On the Yilgarn Craton groundwater discharge has mainly been by evaporation and the decline of shallow watertables is generally observed to taper to a limiting depth of evaporation of about 3 m in wheatbelt valley floors as shown for the watertable hydrograph for site OM5OB in Figure 2.

On the Northampton Block groundwater is mainly discharged as baseflow in the incised drainage. Since 2000, recharge has been less than discharge capacity and groundwater levels have continued to fall as shown in Figure 1.

In the Perth Basin, groundwater discharges as through-flow to the Indian Ocean.

While some rising trends are still observed, the extent of rising groundwater is now much less widespread and the threat of salinity is greatly diminished. If there is a return to more normal climatic conditions, these trends may be reversed.

The most alarming aspect of our observations occurs in the northern Perth Basin which contains regional groundwater systems in extensive aquifers. The Perth Basin is the source of all town water supplies in the NAR. Since 2000 we have observed a switch from generally rising groundwater trends in the northern Perth Basin to generally declining trends.
Determination of the ability of pastures to reduce nitrate-N leaching

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Deep sands are characterised by light textured soils with low water retention capacity. The poor water retention is compounded by the concentration of our annual rainfall falling during winter, when the growth of crops and pastures is low due to the cool winter temperatures and low global solar radiation, resulting in low water usage by these plants.

One consequence of the combination of deep sands and rainfall is nitrate leaching. Nitrate pollution of groundwater stemming from activities associated with agriculture is a common problem, with limited viable mitigation options (Addiscott *et al.* 1991, Guilemin & Roux 1992). The purpose is to investigate whether perennial grasses may be an effective means of reducing nitrate leaching in an agricultural context.

**Soil analysis**

Soil cores were taken from annual, perennial and tagasaste paddocks at intervals through 2007-08. Five replicates were taken at each (sampling to 150 cm), and analysed for total N, NH\(_4\)-N, and NO\(_3\)-N and P content. Drained water from the samples was analysed for NO\(_3\)-N.

**Soil water content**

Volumetric water content was calculated from the gravimetric moisture data using bulk density measurements. These analyses were used to determine budgets for each time interval and compared to neutron moisture meter measurements of volumetric water content at the sites. Figure 1 shows rainfall and evapotranspiration over the growing season.

*Figure 1: Monthly total rainfall and evapotranspiration in the Forsyth paddock, Mingenew*

Figures 2 and 3 illustrate that the perennial grasses use more water within time and depth. With perennials substituted for annuals and tagasaste, it appears that the decrease is about 15 to 30%. Tagasaste appears to use water deeper in the soil profile. There is some equilibrium during low or no rainfall periods.
Water content under pastures during June - October(07)

![Water content chart]

**Figure 2: Volumetric soil water content under pastures at Forsyth paddock**

![Volumetric soil water content chart]

**Figure 3: Volumetric soil water content at Forsyth paddock (lightest colour is lowest)**

**Nitrate leaching**

Figure 4 represents the measurements of soil nitrate-N. The lowest losses are under perennial pastures. Losses are twice as high for tagasaste. The magnitude of leaching losses is affected by rainfall patterns. Nitrate leaching losses during July on all pastures are higher than other months due to the higher soil moisture, while perennial pasture used the highest amount of water in the same month. More nitrogen is taken up by perennials than annuals or tagasaste.
Figure 4: Nitrate-N values under pastures in September 2007 at Forsyth property, Mingenew

References


Environmental assurance and Western Australia’s broadacre industries - gaining the marketing edge

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Despite a long history of involvement with Landcare and other NRM-focused activities, Western Australian broadacre landholders are ‘at risk’ of not meeting community and government expectations for environmentally responsible agriculture, in addition to consumer and market demand for ‘sustainable produce’. This is because there is no universal method or standard of documenting or reporting industry’s on-farm environmental actions.

Farming for the Future has been working with industry organisations to enable WA’s food and fibre industries to “have the information and processes necessary to meet the growing demand to demonstrate that the food and fibre they produce is clean and safe, and is not degrading the environment”.

Through industry engagement, the project has supported industry efforts to implement environmental management systems and food safety systems on-farm, thus raising the capacity to demonstrate the sustainability of WA’s agricultural and horticultural industries.

Sustainability of farming systems is best measured by assessing the level of implementation of acceptable on-farm practices, termed current recommended practices (CRPs) or better management practices (BMPs). There is an expectation from the community and markets that WA’s broadacre landholders use the identified CRPs. These CRPs are set by a range of organisations including government, market, non-government (NGOs) and industry.

Working with research and industry programs within DAFWA CRPs have been defined for WA’s agricultural and horticultural industries. A CRP is “an acceptable agricultural practice” (otherwise called good agricultural practice), while BMPs exceed acceptable practice.

A cross-industry and inter-regional approach has been used to define the CRPs, ensuring that farming practices outlined are acceptable across the regions and industries, and that they can appropriately meet international standards for good agricultural practice where such international standards exist.

The objective is to “minimise land degradation by encouraging development and adoption of management practices which reduce the risk to the resource base”.

Table 1: Sustainability practices

<table>
<thead>
<tr>
<th>Unacceptable or illegal practice</th>
<th>Acceptable practice</th>
<th>Exceeding Acceptable practice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Current Recommended Practice (GAP)</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Exceeding Acceptable practice (BMP)</strong></td>
<td></td>
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</tbody>
</table>

Legal minimum
The CRPs identified by *Farming for the Future* ensure that each industry has a set of identified management practices which are the sustainable for WA farming systems.

In identifying the critical success factors of achieving sustainable management of agricultural resources, the 2007-08 Natural Resource Management Plan (DAFWA 2007) states that “individual farmers or land managers should make business decisions at the paddock and farm scale, which minimise the impacts on both the on-site and off-site condition of the agricultural resource base.” To ensure this happens, while maintaining sustainable growth in WA’s food and fibre industries and markets, the plan states that “WA agriculture needs to:

- maintain or enhance its international competitiveness
- ensure that the resource base used by agriculture is maintained or enhanced
- minimise the impact of agriculture on the surrounding environment
- meet community and political expectation with regard to the environment; animal welfare; occupational health, safety and social welfare; food safety and quality.”

Business decisions made by landowners at the farm and paddock scale are on-farm practice decisions. For example, a landowner will consider tillage methods and pasture varieties, not soil conservation methods or water use capacity (although the relationship between them is often known).

Thus, it is important for industry and research development programs to regularly review their on-farm practice recommendations (CRPs), and influence the decisions of landholders. With good science and industry input, these CRPs will have clear key NRM outcomes by addressing the key DAFWA issues of land degradation; drainage; climate change; water availability and quality; and other threats.

The project has been working with DAFWA’s industry and biosecurity programs to ensure that the CRPs identified lead not only to sustainable natural resource management, but also to sustainable farm business. The *Farming for the Future Self-Assessment Tool* provides a ‘sustainability checklist’ of CRPs for WA primary producers and land managers.

**Defining community and political expectations**

WA’s broadacre agriculture is expected to meet a range of community and political expectations, domestically and internationally. Increasingly these expectations are being defined by importing country governments, major consumers (buyers) and domestic regulators such as Departments of Environment and Food Standards Australia.

One such organisation is the Sustainable Agricultural Initiative Platform (SAI Platform) which has outlined CRPs for many industries including grains, dairy, potato and horticulture. It was established five years ago in Europe as “a food industry platform to support the development of, and communicate about, sustainable agriculture, involving all stakeholders of the food chain” (SAI Platform 2006). Its members include Danone, McDonalds, Nestle, Unilever and other large international food processing companies. An Australian chapter is in a formative stage.

SAI Platform members have developed ‘Principles and practices for the sustainable production of cereals in Europe’ in consultation with a range of stakeholders. This list ‘provides recommendations for producers to continuously improve the sustainability of their agricultural practices’.

The SAI Platform has outlined practices which include:

- Sustainable farming systems
- Economic sustainability
- Social sustainability
- Environmental sustainability.

The Environmental sustainability section calls for European landholders to “limit its impact on the environment” by addressing its:

- Impact on the environment
- Soil conservation
- Water conservation
- Biodiversity conservation
- Waste management
- Energy conservation
- Air conservation.

Some ‘sustainable agricultural practices’ identified by the SAI Platform would be easily met by WA primary producers, while others are not applicable to WA. With this level of practice definition in European markets, it is very important that CRPs for sustainable WA farming systems are identified and promoted. The European community is recognised as a leader in setting community and political expectations with regard to the environment, animal welfare, food safety and quality which other nations watch and copy quickly.

Europe is not the only market making assurance demands of its suppliers regarding on-farm practices. The broadacre industry is starting to feel pressure from some major customers with the implementation of the Japanese Preferred Supplier List in 2006, and expansion of the Chinese Green Label. Both set environmental and food safety standards.

**Defining CRPs for WA’s broadacre industries**

The *Farming for the Future* team is confident that on-farm practices identified through its consultation processes with DAFWA research and industry programs have begun to identify a range of CRPs which can lead to a more sustainable farming system in broadacre industries. There is still considerable work to compile a comprehensive set of CRPs or baselines of CRPs. As new CRPs are developed, the baselines will be updated.

The broadacre industries are beginning to adopt and report on-farm use of CRPs through industry benchmarking and the adoption of environmental management systems.

Industry organisations (AWI, MLA, GRDC, regional councils and catchment groups) are benchmarking the adoption and diffusion of these environmental and production practices. The results will allow individual landholders to compare their on-farm practices to those in their shire, state and industry. In addition, the benchmark data provide industry bodies and regional NRM Councils with the opportunity to assess the adoption of the CRPs and effectiveness of extension activities. These systems, while voluntary and relatively easy for landholders to participate in, do not provide a robust and auditable level of environmental assurance.
If more rigorous levels of community (or market) demand were to be required of WA’s broadacre producers then it would most likely be the responsibility of industries (and perhaps regional NRM bodies) to provide documented evidence of good land stewardship. This would be done most easily through an Environmental Management System (EMS) or Environmental Assurance (EA) processes. *Farming for the Future* has been supporting industries to develop and deliver EMS. Through Australian Government programs the Mingenew-Irwin Group’s (MIG) EMS/EA has been piloted in the South Coast and Avon NRM Council areas. The MIG EMS is aligned with the Betterfarm IQ (Cooperative Bulk Handling’s Food Safety and Quality program which is built on SQF1000™ Multi-site Certification) and provides an audited process which provides producers with ability to demonstrate that they are meeting community expectations for environmentally responsible agriculture and market demand for ‘sustainable produce’.

**Where to from here?**

The area of ‘ethical and environmental’ assurance and marketing is quickly becoming a necessity for market access. Industry and DAFWA research and development programs need to continue to work cooperatively to ensure that the identified CRPs meet market and community demands, yet are practical, sustainable and backed by rigorous research.

There is also need to ensure that these on-farm CRPs are linked to the Management Action Targets and Resource Condition Targets of regional NRM bodies and our corresponding State targets.

Increasingly there will be customer demand from within Australia for targeted environmental outcomes to be set to demonstrate incremental improvement towards sustainability.

Importantly for the NRM Program, we need to ensure that the on-farm CRPs identified lead to good environmental outcomes which reduce the risks from agriculture to the natural resource base.

**References**


Planning for project impact

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We all want our projects to have an impact. To have impact, the first thing to do is to identify exactly what impact is intended and with whom, and plan project activities to deliver specifically to those targets.

**Level of intended impact**

*Direct and ultimate intended change*

It is useful in project planning to identify the *ultimate* intended change, which refers to the final intended change a program or project *aspire* towards. This will almost certainly be a change in improved environmental, social, or economic conditions. Considering ultimate intended change helps keep thinking directed towards longer term outcomes, and adds clarity to identifying direct intended change. In most cases, multiple projects or sources of influence contribute towards achieving ultimate change.

Realistic program/project capacity often means aiming for a lower level than the ultimate change. *Direct* intended change refers to the level of change the project will have direct responsibility for, and will fully achieve through its activities. It is the specific part a project will play in achieving the ultimate intended change. In some cases, the direct intended change for a program or project will be the same as the ultimate intended change. There are usually a number of direct intended changes (often of different levels) associated with a project, which will be reflected in project/extension objectives. The *highest* level of direct intended change should be consistent with overall project purpose and responsibility.

**Levels of intended change**

Four successive levels of change can be used as a guide to identify the level of change a project is aiming for. Level 1, change in awareness, is the smallest suggested level of change, moving up to level 4, improved environmental, economic or social conditions as the highest level of change. Each successive level generally requires greater resources (time, money, expertise etc) to achieve. Levels 1, 2 and 3 refer to a change relating to people, specifically a change associated with your target audience.

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Change in awareness</td>
</tr>
<tr>
<td>Level 2</td>
<td>Change in knowledge, understanding and skills at a generic level</td>
</tr>
<tr>
<td>Level 3</td>
<td>Change in practice or behaviour (small or large scale)</td>
</tr>
<tr>
<td>Level 4</td>
<td>Improved environmental, economic, social conditions</td>
</tr>
</tbody>
</table>

Level 1 refers to a change in awareness (about an issue, topic, practice, situation etc), to a point where the target audience is aware that the topic is relevant (or not) to its own situation.

Level 2 refers to change in knowledge, understanding and skills at a generic level. These elements are grouped because (when planned) they can all be addressed within one activity or event, e.g. a workshop. In this context, ‘generic skills’ refer to more broadly applicable skills, e.g. those observed and practised at a workshop or field day (not tailored to individual needs and situations). This is about increasing level and ends with the individual or group able to make an informed decision about a particular practice or change.

Level 3 refers to small or large scale practice or behaviour change. This is about increasing confidence and motivation to initiate a practice or behaviour change for your own situation.
Scale could relate to either area of intended change or the number of people adopting the intended change (more discussion of scale of change below). The practice change could be either small or large scale on its own merits, or could be a sequential process moving from small scale trialling to larger scale adoption. A positive experience on a small scale can result in increased confidence and potentially greater motivation/desire to adopt on a large scale. A negative experience could equally lead to a decision not to adopt on a larger scale.

What defines small or large scale is a moving target. It will vary with different technologies, different practices, different personal characteristics, and different social, environmental and economic circumstances.

Improved environmental, social, economic conditions (level 4) are potential outcomes resulting from achieving practice or behaviour change at level 3. This level would generally be the ‘ultimate’ level of change agricultural/natural resource management programs and projects aspire towards.

**Scale of change**

Along with level of intended change, it is important to consider and document the scale of a change (which will be related to the target audience and purpose for the change). If for example, a project intends working through planning, implementation and environmental and economic monitoring for surface water management works on a paddock scale, the intended level of change will be high (level 4), but at a small geographic/physical scale.

The same project could encompass additional (or alternative) objectives or activities that aim for a lower level of change, but with a wider audience. The project could, for example, develop and deliver a series of workshops targeted at increasing knowledge, understanding and generic skills (level 2) of all landholders in a region in surface water management.

A project could aim for a flow-on effect from a small number of demonstration sites to a wider target audience. Alternatively, the project could plan to set up a larger number of individual trial sites, and focus on getting a high level of change with the (fewer) farmers hosting each site. In areas where properties are large, large scale practice change could potentially result from working with individuals on a single property, taking them through the learning and trialling process, and providing support for large scale practice change.

**Complexity of change**

In most cases, choosing and planning for a particular level of intended change means planning for all levels of change leading up to that level. Aiming for level 4 for example, assumes planning for levels 1, 2 and 3. This may not be the case for more simple practice changes. Implementing a change such as a new crop variety is relatively straightforward, and doesn’t require major change to current thinking, systems, practices, equipment etc. Project extension aiming for a change in awareness about the crop variety may be all that is needed to effect a large scale practice change. (This should be justified by documenting the situation and logic behind such a decision.)

**Potential influence**

Something else to throw in the planning mix is that while higher levels of change result in longer lasting outcomes, levels 1, 2 and the start of level 3 are where information from outsiders (extension workers, researchers, consultants etc) and social networks are likely to have greatest influence on target audience decision-making. After trialling has commenced, personal experience gained is likely to be the main influence on further decisions (Dong and Saha 1998, Marsh et al. 2000, cited in Pannell et al. 2006).
Identifying target audiences for change

Separating target audience/s for change from partners and funders is a useful concept in extension planning, as it guides thinking, and therefore extension activities, towards the actual impact a project hopes to have. This is particularly relevant to research-dominant projects which typically have little or no extension component focused on change or impact.

The target audience for change may be the end user, describing individuals or groups responsible for implementing the final (usually on-ground) change. In agriculture and natural resource management, end users are usually farmers and other land managers.

Alternatively, the target audience for change may be intermediary individuals or groups in the influencing process, also known as a next user. Next users may well target the same end user as your project. In agriculture and NRM, potential next users include regional groups/officers, private sector consultants, agribusiness, farmer groups, local government officers, State agriculture/primary industries agency programs, other government agencies, and more. The intermediary may have stronger relationships and influence than a new or short-term project could expect to have.

An important part of planning for impact is identifying all strategic target audiences for change, and understanding their needs sufficiently to tailor project information, products and services directly to those (and other project) needs. In the case of next users/intermediaries as a target audience, their needs will relate to the needs of their target audience. For all target audiences, it is essential to form ongoing relationships, including feedback loops, to keep up to date with the information needed to better design and deliver project impact.

Choosing extension activities to match level of direct intended change

Once a project has clarified its direct intended change(s) and for whom, the next step is to choose extension activities that are congruent with that change. The Extension and Communication project has developed a tool which helps do this, designed to help planners with little extension knowledge or experience design activities meet their stated project/extension objectives.

Activities for level 1 - change in awareness

- About attracting the attention of the audience to the point they are aware it is relevant to them
- Written material needs to incorporate elements of credibility, relevance, positive characteristics of the practice itself, a hook, appropriate language, readability, good layout etc.
- Can include non-targeted mass media mechanisms such as locally relevant newsletters, rural newspapers, TV and radio, websites, Farmnotes, Agmemo or can be targeted more directly
- Can include physical cues such as signage, stickers, badges, hats, stationery, T-shirts etc.

Activities for level 2 - change in knowledge, understanding and skills at a generic level

- Any activity which facilitates information exchange and discussion between target audience members, and between target audience and others.
- Could include workshops, field days, training courses, seminars for your target audiences that incorporate adult learning principles and theory, expert or peer demonstrations, show-casing strong and/or locally relevant case studies, interactive web-based educational learning groups etc.
• Application of adult learning principles and theory (Knowles 1990, Mumford 1993, Malouf 1994, McGill and Beatty 1995, Burns 1998 and others) is valuable when developing activities and events at this level
• It is worth considering that a well informed decision not to initiate a particular practice change is just as valuable as a well informed decision to make the change.

Activities for level 3 - change in practice or behaviour (small or large scale)
• Activities which increase confidence and motivation to act and support physical actions
• Could include financial incentive for establishing and managing small scale trial sites, (free trees, free soil sampling and training subsidies), skills practice at own site, access to technical expertise, site-specific peer networks, site-specific resource packages etc.
• Comment on community level practice or behaviour change - a community is likely to resist change being imposed from ‘above’, without opportunity to consider or influence. Where you are aiming for practice or behaviour change on a community level, the key is for individuals within that community to develop ownership of the change.

Activities for level 4 - improved environmental, economic, social conditions
• Not activity-based
• Need to have clearly described the program logic (or cause-effect relationship) that theoretically supports the change. This allows us to demonstrate exactly how (and why) one step should lead to the next, for any particular situation. This, in turn, supports confidence in attribution (or partial attribution) for evaluation purposes.
• Evaluation is also a key element of this level.

Final comment

We need to identify exactly what impact is intended and with whom, and plan project/extension activities to deliver specifically to those targets.

To the future:
• All projects need to think about impact, whether going all the way to level 3 or 4, or just to raise awareness on a small scale. Even in the purest of research projects, there should always be some communication of results.
• Projects need to be very clear about the level and scope of their direct intended change, before finalising project purpose and objectives.
• There is an opportunity to think much more strategically about target audiences for change, particularly identifying and working with potential next users/intermediaries.
• Projects (and the Division) need to think about the gap/steps to on-ground change. What happens to the information/product/service after it ‘leaves’ my project? Is there anything that can be done within my project to facilitate this movement?
References


Acidic groundwater in the South West of Western Australia: Its distribution, causes and implications for agriculture

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Acidification of inland waters was identified as a threatening process in the 2007 Western Australian State of Environment Report. Acidic groundwater, when drained, potentially poses a risk to the environment, agriculture and infrastructure with the resulting economic costs. Some of the impacts of environmental acidity include: ecological damage to aquatic, terrestrial and riparian environments, death and disease in aquatic and semi-aquatic organisms such as macro-invertebrates and frogs and corrosion of concrete and metals causing damage to culverts, building foundations, roads, water pumps and underground pipes. There are various sources of acidification of inland waters, the most relevant for agriculture is groundwater and to far lesser extent, acid sulfate soils.

Due to the region’s geologic and climatic history, salt has accumulated in the regolith. The removal of native vegetation for agriculture has changed the hydrology of these landscapes. This has resulted in greater recharge to groundwater causing it to rise. Consequently, over a million hectares of the south west are affected by dryland salinity. The areas are increasing and it estimated by equilibrium between 15 to 30% of the region, or potentially 3 to 5 million hectares, may be affected by shallow watertables if trends (1975-2000) are unchanged by climate (Clarke et al. 2002, Ali et al. 2004, George et al. 2005).

Much saline groundwater in the agricultural regions is naturally acidic. The reason is not fully understood but is thought to be caused by the oxidation and hydrolysis of ferrous (Fe^{2+}) iron (Mann 1983, McArthur et al. 1991, Gray 2001). The processes leading to salinisation are also potentially increasing the extent of acidification.

One of the main tools for managing salinity is to use plants to reduce recharge and thereby lower watertables. However, over much of the grain producing area, almost the entire landscape needs to be revegetated with perennial-dominated systems to have significant impact. Additionally, there are few economically viable plants available in low rainfall areas for recharge control. Therefore farmers are looking to engineering solutions such as drainage, despite problems with cost and hydrologic effectiveness. It is hoped by putting in drains or pumping to lower groundwater levels that land will be returned to productivity, or protected from future risk (Clarke et al. 2002, Ali et al. 2004, George et al. 2005).

Agricultural practices such drainage are large contributors to acidification of inland waters. The Department has responsibilities under Soil and Land Conservation Regulations 1992 to assess drainage or pumping for salinity to ensure it will not result in degradation. Therefore, acidic groundwater could emerge as a significant natural resource management issue.

The environmental acidity project seeks to minimise land degradation by encouraging development and adoption of practices which reduce the risk to the natural resource base and minimising off-site impacts. It is contributing to meeting the resource goals: Nutrient and chemical export from catchments below the assimilative capacity of receiving water bodies; and Integrity of terrestrial and aquatic ecosystems maintained/enhanced.

The project also addresses the following NRM Priority Outcomes:

- Agricultural industry being informed by the assessment of natural resource risks and the evaluation of strategies to reduce the environmental impacts of agriculture
- Improved management of agriculture’s resource base through an understanding of its status and trends
• Improved water resource management to meet the economic, environmental and social needs of the community.

The project was funded through the Natural Heritage Trust Regional Competitive Component and is a partnership between DAFWA (project manager), the South West Catchments Council, South Coast Natural Resource Management Inc., the Chemistry Centre of WA and the former Department of Environment (now Departments of Environment and Conservation, and Water). The focus was originally on acid sulfate soils, but through time it was realised that agriculture was only a relatively minor contributor to acid sulfate soil disturbance, however agricultural practices were having major disturbances of acidic groundwater in the drier regions. Therefore the project switched most resources to inland acidic groundwaters.

The project has over 3 FTEs and the outputs (Figure 1) cover four main themes: research on the origins, distribution and impacts of acidity; extension activities; water treatment systems; rehabilitation techniques for scalds and development of decision support tools.

Research on the origins, distribution and impacts of acidity

Figure 1: Trial sites for project activities
The team has worked with other agencies and projects (i.e. Engineering Evaluation Initiative – Acid Groundwater Projects) on the origins and distribution. Groundwaters show a distinct bi-modal distribution and acid groundwaters are widely distributed across agricultural regions, most frequently in the eastern wheatbelt and Esperance Mallee (Figure 2).

- Monitoring on the western South Coast and Peel-Harvey looking at the possible impacts of acid sulfate soils on water quality
- Research on the impacts of agroforestry on acid sulfate soils.
- Impacts of acidic deep drains as part of the Fitzgerald Catchment Demonstration Initiative.

**Extension on acid sulfate soils/acidic groundwaters**
- Conducted full-day workshops in Bunbury and Albany
- Field days and public presentations to landholders
- Awareness raising activities with department staff.

**Water treatment systems**

Adaptation of water treatment technologies used by the mining industry to treat acidic waters for use in natural resource management. The first treatment system has been designed and is soon to be constructed.

**Site rehabilitation techniques**

Developing rehabilitation techniques for acid sulfate soil scalds and acid saline groundwater seeps.
Decision support tools

- Assisted developing acid sulfate soil risk maps for Esperance
- Developing acid groundwater hazard maps
- It is a pilot project and we are currently working with DoW, DEC and Regional NRM groups to develop a multi-agency cross-regional project to manage acidic groundwaters to bid for Caring for our Country funds.

References


Reducing nitrogen and phosphorus leaching from feedlots using *Green Pad* bioremediation

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Dairy farmers in the South West commonly hold their herds in small areas close to the dairy to facilitate hand-feeding. This practice leads to the accumulation of high nutrient loads which pose a serious risk to both local and regional water quality. Due to the higher input of nitrogen (N) over phosphorus (P) in animal excreta, the major nutrient contaminant of interest is nitrate. Our study assessed the use of a microbially mediated groundwater treatment called Green Pad that resulted from the burial of woodchips below the surface of a hydrologically isolated loafing pad. The hydrological isolation forced excess water on the pad to pass through the woodchip layer prior to drainage into a holding pond. In the woodchip layer, microbial transformations of both N and P occurred via either immobilisation or dissimilatory reduction to gaseous forms that can potentially reduce N and P concentrations in the leachate.

Two adjacent loafing pads were constructed on the Vasse Research Centre on the outskirts of Busselton, each being 1600 m² in area (i.e. 40 × 40 m). The pads were 1 m deep and filled with sand (control pad) or half sand and half woodchips (Green Pad) by volume, with the woodchips centred in the pad’s profile (Figure 1). Holstein cows were enclosed within the pads on 10 occasions between May 2006 and July 2007, and deposited N and P in cow excreta were estimated from established relationships for nutrient intake, utilisation and excretion from similar feed-lotted animals. Effective precipitation was calculated from estimates of deposited animal fluids, rainfall and evaporation. Samples of leachate from each pad were collected at the same time on 37 occasions, more frequently in 2007. Leachate samples were analysed for concentrations of N and P (total and ionic), pH and EC. Results are presented in Figure 2.

Total effective precipitation was 770 mm and the leachate volumes from the loafing pads equated to 294 mm (38%) and 146 mm (19%) for the control pad and Green Pad, respectively. The Green Pad had substantially lower total-N, ammonium-N and nitrate-N concentrations in its leachate at every sampling. There was almost no trace of nitrate-N or ammonium-N in the Green Pad leachate, and the total-N leached was only 8% of that from the control pad (65 kg), a very modest 5 kg. The mass of total-P and phosphate-P leached from the Green Pad was about half that from the control pad (5.2 versus 2.5 kg).

While the very large reductions in N leached from the Green Pad were expected, the large reduction in P loss was not, especially given the enhanced P load from the woodchips. The substantial reduction in P was attributed to the reduced volume of leachate from the Green Pad, even though the P concentrations in leachates were noticeably lower in 2007.

Leachate removal of N and P from the control pad constituted a remarkably small amount of the load within the loafing pad, less than 6% of the N and 2% of the P. The only plausible explanation for this very aggressive remediation is that denitrification activity was rapidly established in both pads. However, this was substantially higher in the Green Pad due to greater availability of reduced carbon, and/or enhanced residence time of the soil solution. For P remediation, it seems possible that the soil reduction potential of each pad may have been sufficiently low as to favour the conversion of phosphate-P to phosphine (PH₃). This is a naturally occurring but highly unstable gaseous product of anaerobic activity that has been shown to be responsible for the loss of 25-50% of P from open-air sewage treatment plants in Europe. Furthermore, the carbon-rich environments of both pads, but particularly the
Green Pad, provided very large potential for microbial immobilisation of both N and P within the pad.

Bioremediation of N and to some degree P, from point-source pollution sites can be readily performed cost effectively with woodchips in a hydrologically isolated area. It is uncertain how long the bioremediation potential of these materials will last, and this requires further research on their in situ decomposition dynamics. Nevertheless, it seems reasonable to expect at least 20 to 30 years for the design used in this study. Appropriate precautions in managing animal welfare within small areas should not be a major factor in preventing their adoption. What remains to be tested is pad performance at more commercial stocking rates.

Acknowledgements

The authors acknowledge the generous support of the South West Catchments Council, Natural Heritage Trust, Western Australian Government, Dairy Australia and Western Dairy for the opportunity to implement and evaluate the Green Pad remediation technology.

Figure 1: Layout of the Green Pad trial
Figure 2: Cumulative masses of precipitation (a); leachate volume (b); leachate nitrogen (c); leachate phosphorus (d); leachate pH (e); and EC (f) trends across the sampling dates.
Setting catchment and regional scale salinity targets in the South West NRM Region

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Dryland salinity is a major threat to the natural resource assets of the South West Natural Resource Management (NRM) Region. Regional groups such as the South West Catchments Council (SWCC) require targets that identify desirable, achievable future states of regional natural resources. The National Framework for NRM Standards and Targets (NRM Ministerial Council 2002) specifies that medium-term (10 to 20 years) resource condition targets that are specific, time-bound and achievable are required for land salinity, among other matters.

The South West Region NRM Strategy (SWCC 2005) contains a provisional resource condition target for land salinity, which is time-bound but not specific: “Total area of land affected by dryland salinity no more than X times the 2004 area at 2020.” The strategy identified the need to set resource condition targets for land salinity in priority catchments. SWCC’s first investment plan commissioned the Department of Agriculture and Food to develop and test a method to set targets in priority catchments in the low and medium rainfall parts of the region. SWCC’s second investment plan requested DAFWA to set regional scale targets as well. This paper outlines the processes used to set salinity targets at both catchment and regional scales.

Contribution to natural resource management outcomes

The project aligns with Departmental strategies by directly assisting regional groups to develop resource condition targets, specifically for land salinity. The targets directly influence public and private investment in the management of land salinity (Strategy A1) and closely align with the goal to manage salt-affected and waterlogged soils for production and minimising off-site impacts. The project focuses on the two NRM priority outcomes: resource condition monitoring and evaluation; and influencing the investment of regional NAP/NHT funds. DAFWA's 2007-08 initiatives for the State Budget list the of development ‘technical’ resource condition targets for land salinity in catchment areas in the medium and low rainfall zones of the South West region.

Analysis of regional rainfall and groundwater trends

Regional trends in rainfall, groundwater and salinity were analysed for each of the soil-landscape zones within the project area. Growing season rainfall (May to October) has significantly decreased across most of the area since 1975. Over this same period groundwater levels have risen and continue to rise across most landscapes. Groundwater levels on some lower slopes and valley floors, particularly in eastern parts, have reached, or are close to, equilibrium. Very few bores exhibited falling groundwater trends. Additional groundwater bores are required to complete the monitoring network and monitoring of some existing bores will need to be reinstated. The results of this analysis and recommendations are reported by Raper et al (in prep.)

Setting resource condition targets in priority catchment

Hu’s 2006 review of target setting at regional and catchment scale across Australia and New Zealand recommended consultation. A Community and Stakeholder Reference Group was established in 2006 to facilitate regional consultation specifically to prioritise catchments for
target setting workshops with catchment groups and to help develop and test the target setting workshop process.

In 2006, workshops were held with five groups (East Yornaning, Daping Creek, Fence Road, Querfellows Creek and Farmers with a Future Vision), followed by a further seven groups in 2008. Catchment size ranged from 7,700 to 41,500 ha. The process consisted of two half-day workshops facilitated by a consultant. Up-to-date information on groundwater trends and salinity hazard at regional and catchment scale (if available) was presented and compared with local landholders’ experience. Simple models such as Flowtube were used to demonstrate the likely impacts of management options and help the groups agree to catchment scale resource condition and management actions targets for land salinity.

Due to the lack of long-term data at catchment scale on groundwater levels and the availability of Land Monitor information, targets were based largely on analysis of Land Monitor data for each catchment. Landholders identified significant areas that they believed were saline in 1998-99, the last processing date for Land Monitor analysis, that were not shown on the images of current extent of salinity for their catchments. The main causes of omission were samphire and other salt-tolerant vegetation masking saline land. In only one case was a 2000 landholder estimate of salt-affected land available for direct comparison with the Land Monitor current extent data. In this case the Land Monitor mapping underestimated the salt-affected area by 45%. Comparison of the 2006 and 2008 estimates of salt-affected land with the Land Monitor 1998-99 statistics revealed under-estimates from 22 to 83%, with a mean value of 44%, indicating that the 45% under-estimate for the one catchment available was at the upper end of the range.

At the start of the workshops, most participants aspired to recover their land from salinity. After the technical presentations, most participants agreed to targets that reflected a containment of, or limitation to, the extent of future salinity in their catchments. These targets were still optimistic given the current knowledge and understanding of groundwater and salinity trends, the likely minimal impact of management interventions agreed to by participants and the capacity of individual landholders to fund the required interventions. Many landholders were optimistic that advances in knowledge and technology would help reach these targets. Targets aimed to increase the productive capacity of land currently affected by salinity and adopt farming systems to improve overall farm profitability. Overall, the resource condition targets were specific and time-bound but it is not clear how achievable these targets are. Most targets were set without the expectation of additional public funding but also recognised that landholder capacity to make changes at the scale required is limited.

The management actions considered by landholders included deep drainage, improved surface water management, improved flow continuity along main streamlines, revegetation of non-productive land, perennial pastures and salt land agronomy. Participants did not consider large-scale revegetation with oil mallees or other commercial trees favourably. Landholders generally viewed engineering options as more effective than plant based options although improved productivity of saline land was also a high priority.

The project team faced some challenges. Most groups had stopped meeting. Many had been disappointed that past planning had not led to significant levels of public funding. It was important that the project team did not raise group expectations of services or access to public funding. Participating groups were not guaranteed funding, although an Expression of Interest process for limited funding is being run in 2008. Staff turnover and recruitment delays affected progress, with no work between March and September 2007. Consultants were used to fill staffing gaps and draft reports were prepared to minimise loss of intellectual property (Percy in prep, Keipert et al. in prep).
The buzz from the project is the renewed enthusiasm from farmers to tackle their salinity problems and take a realistic view of their options for doing so. The project also improved relationships between DAFWA staff and community-based NRMOs.

**Setting regional scale targets**

In late 2006, SWCC identified a need for regional scale land salinity targets that reflected the likely level of landholder intervention. Data from the regional groundwater and salinity trends analysis, specifically the Land Monitor valley floor hazard (AHAVF at 0 to 0.5 m height increment) data, were used with National Land & Water Resources Audit salinity risk estimates and study catchment data to estimate the area of salt-affected land within each soil-landscape zone in 2020.

The estimates were based on two assumed levels of intervention:

1. Continue with current farming systems and do nothing differently
2. Most likely, strategically distributed interventions under current levels of investment.

These assumptions were documented in the South West Regional Strategy for NRM (SWCC 2005). The estimates for salinity risk for each major soil-landscape zone are in Table 1.

**Table 1: Estimates of salinity risk for 2020 based on current practices and most likely interventions (% of soil-landscape zone)**

<table>
<thead>
<tr>
<th>Soil-landscape Zone</th>
<th>Continue current farming practices</th>
<th>Assumed most likely interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Darling Range (253)</td>
<td>8%</td>
<td>5%</td>
</tr>
<tr>
<td>Southern Zone of Rejuvenated Drainage (257)</td>
<td>15%</td>
<td>12%</td>
</tr>
<tr>
<td>South-western Zone of Ancient Drainage (259)</td>
<td>20%</td>
<td>19%</td>
</tr>
<tr>
<td>South-eastern Zone of Ancient Drainage (250)</td>
<td>10%</td>
<td>9%</td>
</tr>
</tbody>
</table>

The estimates of salinity risk at 2020 were used to assign technical land salinity targets for each soil-landscape zone. These were aggregated on an area basis to a single, technical land salinity target for the region (Percy and Raper 2006). SWCC’s Salinity Program endorsed the suggested regional ‘technical’ land salinity target: “The total area of land affected by dryland salinity in the medium to low rainfall portion of the South West NRM Region to be no more than 12% at 2020.”

GHD have been contracted to survey landholders across the four soil-landscape zones. The survey will follow a similar process to the target setting workshops. It will explore landholders’ aspirations for salinity over the next 20 years and seek their views on the effectiveness of previous interventions. It will also test the assumed levels of interventions that form the basis of the technical target. The survey results will be combined with information from the target setting workshops and barriers to adoption studies into surface water management, perennial pastures and farm forestry to revise the regional scale salinity targets.

The amalgamation of the survey results with technical targets set by DAFWA staff and catchment-scale targets will provide SWCC with a regional land salinity target that is not only specific, time-bound and achievable but also reflective of the aspirations and intent of landholders directly affected by dryland salinity. Groups with targets have used the documented outcomes and targets for planning and accessing public funding to work towards their short to medium term targets.
Acknowledgments

The project is an initiative of the South West Catchments Council and funded jointly by the State and Australian Governments under the National Action Plan for Salinity and Water Quality. The project has been strongly supported by the Blackwood Basin Group and the Peel-Harvey Catchment Council through their participation in the Community and Stakeholder Reference Group along with officers from CALM/DEC. Local NRM Officers played a vital role by encouraging landholder involvement and providing follow-up after the workshops. They also supported the project team in planning the logistics of the workshops such as venue, dates and timing.

The project team consists of Paul Raper, Sharon Hu (2005 & 2006), Nardia Keipert (2007), Leon van Wyk (2007 & 2008) and Heather Percy. Jane Kowald, Richard George, Tim Mathwin, Eric Wright and Michael Smith made valuable contributions. Short-term expert input was provided by Peter Eckersley (Eckersley Rural Consulting), Viv Read (Viv Read and Associates), Andrew Huffer (Andrew Huffer and Associates) and currently GHD.

References


Climate change – DAFWA policy and research activities*

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Policy development regarding climate change is progressing at a rapid rate. This presentation will summarise the climate change policy positions to date at a national and State level and discuss the climate change policy and research activities that DAFWA is involved in (including the Climate Change Adaptation project currently before Treasury).

The newly-formed DAFWA Climate Change Reference Group will be introduced and attendees will be invited to discuss proposals they wish the Reference Group to address to achieve better coordination of climate change policy and research development across the Department.
Waterwise on the Farm in Western Australia

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The aim of Waterwise on the Farm (WWOTF) is to improve Water Use Efficiency (WUE) in irrigated agriculture in WA. This can be achieved by assisting irrigators to gain and implement nationally recognised competencies in irrigation application efficiency and management (of participating landholders) within Western Australia.

Water is crucial to Australia’s natural and economic wealth. It is the basis of our agricultural industry - one of Australia's largest. The National Water Initiative (NWI) aims to increase the productivity and efficiency of water use, sustain rural and urban communities, and to ensure the health of river and groundwater systems. The WA Government has endorsed these principles and signed the Intergovernmental Agreement on the NWI. WaterWise on the Farm addresses two key elements: ‘Knowledge and Capacity Building’ and ‘Community Partnerships and Adjustments’.

The State Water Plan (2007) has identified that Western Australian communities and industries are reliant on access to reliable water supplies that provide adequate scope for community and economic growth. Water supply is one of a few key drivers and prerequisites for economic and social development.

In WA, the agricultural sector takes around 43% of water used (40% in irrigation, 3% in stock water), compared with around 60 to 80% nationally. Around 780 GL of water is allocated annually to agricultural industries. This is estimated to increase to 1,150 gigalitres by 2030, assuming moderate growth. The Irrigation Review (2005) estimated that around 46,000 ha of agricultural land is irrigated annually contributing $800 to $900 million to the State economy, providing an essential supply of fresh fruit and vegetables for domestic and export markets, and supporting regionally significant wine and tourism industries. The agricultural use of water could increase even further in coming years with major expansion of irrigated agriculture planned for the Kimberley (Ord Stage 2), and smaller developments at Gascoyne and Greenough based on groundwater resource development (State Water Strategy 2003).

Water for irrigation is supplied from different sources including large dams in the Darling Scarp and the Kimberley, groundwater aquifers across the State, and surface water catchment dams on individual farms.

Through climate change there has been a 10 to 20% reduction in annual rainfall and a shift in the rainfall patterns. This has resulted in a 40% reduction in runoff into surface water catchments and the same level of reduction into groundwater recharge. The State Water Strategy (2003) identified that water use efficiency is now an essential part of water resource management. The strategy also identified that all water use sectors and the broader community needed to take action to improve water use efficiency over the next 10 years.

Methods

The main objective is to improve the capacity of land managers to use irrigation water in a more sustainable way by increasing their skills and knowledge in sustainable irrigation management, and by offering limited financial incentive to improve their irrigation systems. The incentive is designed to leverage industry investment in improved irrigation infrastructure, providing the important on-ground component of the project, while the irrigation training would ensure that the investment actually resulted in gains in water use efficiency.
The training courses and individual follow-up is the main focus of the project. By increasing the skills and knowledge of irrigation managers significant gains in water use efficiency can be made.

The training course is made up of one introductory workshop and three formal workshops plus individual farmer support.

At the end of the first workshop, Assessing your soil and water resources, participants are able to:
- identify soil layers
- identify soil texture
- identify the crop’s effective root zone
- understand how soils hold water
- calculate a soil’s readily available water (RAW), which indicates how much water is available to the plant
- sample soil and water to check their suitability for irrigation.

After the second workshop, Evaluating your irrigation system, the participants are able to:
- identify the importance of irrigation efficiency
- measure and record the performance characteristics of an irrigation system (including Distribution Uniformity and Mean Application Rate)
- discuss irrigation system performance parameters and their impact on total water use and crop uniformity

At the end of the third workshop, Scheduling and benchmarking, participants will be able to:
- determine crop water requirements
- compare irrigation scheduling methods and tools
- develop an irrigation schedule
- develop a seasonal irrigation budget
- identify the benefits of water use efficiency benchmarks for their farm
- identify the information needed to benchmark water use efficiency for the farm.

The second component was the irrigation improvement grants process. People who had completed the training course and developed an irrigation management plan could apply for a grant to improve their irrigation system or management. The grants were $2,000 per business at the start, but increased to $4,000 to stimulate uptake. This proved very effective.

The third component is the use of demonstration sites to show the latest innovations and research into irrigation management. Four demonstration sites were set up on farms representing different irrigated industries. The demonstration sites added value to the project by providing participating landholders with concrete examples of the principles discussed during workshops. This has resulted in a comprehensive investment program aimed at achieving improved on-ground irrigation efficiencies.

**Achievements**

*Waterwise on the Farm* (WWOTF) was established as a pilot project in 2002-03. Its aims were to develop a suitable irrigation training program to increase water use efficiency by irrigators, and to determine the level of interest among irrigators in WA.

The project expanded on the training model and information originally developed in NSW. The training material from NSW was customised for WA and specific industries.

The training was delivered to small groups of farmers to enhance the adult learning process. Each group had four formal workshops on specific irrigation management topics, including
assessing farm soil and water resources, evaluating the existing irrigation system efficiency, scheduling irrigation and benchmarking against others performance, and preparing an Irrigation and Drainage Plan.

The addition of the one-on-one training from the start of the 2004/05 season as follow-up to the workshops has increased the cost of the course per participant, but feedback from the participants has shown that it is one of the key features that contribute to changes to irrigation systems. Rebates were available to irrigators to upgrade irrigation systems, based on an approved irrigation plan, up to $4,000 per irrigation plan.

Funding for WWOTF over the past three years has been provided by the National Landcare Program, Department of Water (2006-07), Department of Premier and Cabinet – Office of State Water Strategy (2004-06), Department of Agriculture and Food, South West Catchments Council and farmer contributions. This has enabled it to achieve the following milestones:

• Development of training material for WA – editing and enhancing the NSW material
• Delivery of 31 training courses (124 workshops) over five years, 290 farmers trained so far from Carnarvon to Albany
• $360,000 worth of Irrigation Improvement Grants processed
• Three staff trained in the delivery of Waterwise on the Farm for WA conditions
• Two irrigation consultants trained to deliver specific WWOTF workshop components
• 105 irrigators will have accessed the grant rebate to upgrade irrigation systems this year
• Upgrading a Seasonal Water Use computer program (Irricalc) for use in WA
• Liaison with the Department of Water on irrigation management training of farmers – improving water use efficiency. Raising awareness of what Waterwise on the Farm training can achieve
• Formation of an Industry Steering Committee to ensure the training stays relevant to each irrigation industry
• The project has attracted funding from the Natural Heritage Trust (NHT) and National Landcare Program (NLP) during 2004/05, 2005/06 and 2006/07, secured in part through the South West Catchments Council
• Development of four demonstration sites for Irrigation and Nutrition Best Management Practices in association with related industry programs within the Department of Agriculture and Food, mainly funded through the South West Catchments Council.

External evaluation in April 2004 and February 2007

The two evaluations were focused on the training course component. The implementation and operation of the demonstration sites is in the early stages and evaluation of their effectiveness would not reveal useful information.

It was decided to use external marketing firms for evaluation to remove any bias that may occur if the people involved with the project did the evaluation. Using an external marketing firm also allowed the participants to be more frank about the training courses.

In both evaluations the participants were generally very satisfied to satisfied with the training and had put into practice what they had learnt from the training courses. One impression that the marketing company personnel came away with was the enthusiasm of the people they interviewed when talking about irrigation management.
The participants of the courses appear to be motivated to attend the training because of, a recognised need to improve water use efficiency, a change in current water supply or a desire to build on their current knowledge with the latest information.

The most frequently mentioned learnings identified from the two evaluations were:

- Better understanding of soils and their water-holding capacity
- Understanding irrigation scheduling – watering intervals
- How to check their systems
- The importance of distribution uniformity
- Identifying the watering requirements for specific plant types.

This is a very good indicator that the training has been effective since these concepts are the key components of the training course.

The evaluations highlighted the importance of using good adult learning techniques, small groups, practical hands-on training activities and the need for individual follow-up as part of the training. The evaluations also identified that further contact with the people completing the training i.e. 6 to 12 months after completing the course would stimulate further management changes.

The latest evaluation highlighted the need to form specific industry groups i.e. citrus, pasture, fruit irrigation etc. This was identified as a preferred option for training. This will necessitate greater involvement from grower organisations in forming training groups in the future.

The findings from these evaluations will be incorporated in the new National Landcare Program project where practicable.
The Greener Pastures project - a good model for effective NRM integration with industry?

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One area of common interest between the dairy and other grazing industries is the drive to increase pasture utilisation to address the constant cost-price squeeze. Many DAFWA trials demonstrated high economic responses (8-12 c/kg DM extra pasture) to strategic use of nitrogen (N) on dairy farms. The rapid and perhaps extreme increase in nitrogen use (up to 3 kg/ha/day of applied N) on Australian dairy farms since 1990 is based on the assumption that more nitrogen equates to more pasture, which results in more milk, and consequently more profit. While plant growth responses to nitrogen are well documented and relatively easy to predict, the introduction of the grazing animal makes the assumption that more nitrogen leads to greater profitability less predictable. The history of other grazing industries adopting common dairy practices (e.g. controlled/rotational grazing as a means of making better use of home-grown feed to increase stocking rates) is being repeated as beef and sheep producers start to also use N fertiliser to grow more grass.

The grazing animal is a very inefficient user of nitrogen from plant material. Ruminants typically excrete 70-80% of their total nitrogen intake in urine and dung. Urine patches in dairy pasture contain nitrogen concentrations of up to 1000 kg/ha, greatly exceeding the uptake capacity of pasture plants (Ryden et al. 1984). Surplus nitrogen, which escapes use by plants, can be a major cost to livestock farmers. Nitrogen balances for intensive irrigation WA dairy farms indicate unproductive surpluses of over 400 kg/ha/year (>500 ha/year). Reducing this surplus through lower fertiliser input or techniques that allow better use by plants, represents opportunity for both productivity and sustainability improvement.

The increased use of N to intensify dairy production is a worldwide trend as farmers respond to the persistent cost-price squeeze and has led to strict nutrient regulation in New Zealand, the US and the EU. From an environmental perspective, WA grazing industries are being increasingly challenged to manage high performance pasture systems that meet the expectations of a community that is increasingly sensitive to environmental issues. Locally, sensitivities include the Peel-Harvey Estuary, Vasse Wetlands, Geographe Bay and nutrient leaching to useful Perth Basin aquifers.

The WA dairy industry is collaborating with DAFWA and other government departments and organisations to identify opportunities to use nutrients more profitably while protecting the environment. Led by the Department of Agriculture and Food’s dairy team, Greener Pastures is a five-year farming systems project that aims to clearly define the milk production response to nitrogen fertiliser in a pasture system; determine the nutrient footprint of intensive grazing systems under local conditions; and demonstrate practical ways to use N (and phosphorus, P) more profitably and sustainably. This will enable the dairy industry (and other grazing industries) to develop N and P use guidelines that improve efficiency and address growing sensitivity of the broader community to the environmental impact of intensifying farming practices.

Methodology

Greener Pastures requires a complex science and extension strategy and therefore interdisciplinary participation from a wide range of stakeholders. DAFWA Dairy Project investment of $2M/yr (mainly salaries) clearly demonstrated the State Government commitment to the project and attracted Dairy Australia investment of $0.25M/yr and Western Dairy investment of $0.1M/yr to follow. This enabled the project to be ‘industry or
community-badged’, as appropriate, attracting an additional $0.5M from external sources such as NHT/NLP, LWA, CSIRO and CCWA. These extra sources have mainly enabled the more NRM-focused catchment and industry-scaled investigations into runoff and groundwater contamination impacts at various scales of intensification.

Extensive collaboration with industry influenced design so that instead of research being the central focus; it is farmers and industry in collaboration with researchers that drives the system. Western Dairy board members were integrally involved in project design and development. Other stakeholders such as WAFarmers, processors and consultants have been regularly consulted and involved. This has ensured a whole of industry approach to defining the issue of increasing nitrogen use in intensive dairy systems, identifying research and opportunities to overcome constraints and planning for testing the opportunities with farmers and encouraging widespread industry adoption of the improved farming systems.

Detailed production and environmental process/response investigation is undertaken using a farmlet system approach at Vasse Research Centre (VRC). Five independent farmlet herds (5 rates of N; 0-2 kg/ha/day) are continuously monitored for production as well as nutrient leaching and runoff responses. Additionally, two large ‘innovation’ herds at VRC (dryland and irrigation) and four commercial ‘partner farms’ are used to test the production and environmental implications of farm scale management changes and obtain some much needed baseline data at these scales on which sound management changes can be based. The ‘production scaled’ units were included not only to ensure that the ‘smaller scale science’ was relevant (production systems developed are based on science and real farm experience) but also because farmers are more likely to adopt new technology if they believe it is practical, viable and relevant.

**Key results and discussion**

*Production focus*

One method for evaluating nitrogen use is to calculate N efficiency (‘output/input ratio’) as part of a farm nutrient budget. This accounts for all N inputs in terms of fertiliser, fixation, purchased feeds and livestock, and all outputs in terms of milk, forage and livestock. Nitrogen surpluses increased over 700% and efficiency declined from 59 to 26% for a pasture system using 2 kg N/ha/day and stocked at 2.25 cows/ha (Farmlet 5) compared to a system using 0 kg N/ha/day and stocked at 1.25 cows/ha (Farmlet 1). Total pasture utilisation (t DM/ha) peaked at between 0.5 and 1 kg N/ha/day (Farmlet 3). Pasture nitrogen efficiency (kg total pasture DM/kg N applied) was also highest at 0.5 to 1 kg N/ha/day). The optimal N rates are likely much lower than recent industry direction, and already the local industry is curtailing N use because of these findings, which are particularly significant in the light of recent fertiliser cost increases.

As farmers have increased their nitrogen use many have increased their rotation speeds in response to ‘canopy closure’ due to increased pasture growth. Results show that the increase in rotation speed cancels out part of the potential pasture growth response from nitrogen fertiliser and adversely impacts on the nutritional balance of pasture for dairy cows. By grazing at 2½ leaves, increasing fertiliser N from 1 to 2 kg/ha/day increased pasture growth rate by 34 kg DM/ha/day. However this potential was significantly reduced to 17 or 10 kg DM/ha/day if rotation speed was increased and pasture grazed at 2 or 1½ leaves respectively as pasture growth rates increased due to higher rates of nitrogen.
Environmental focus - nutrient leaching

Monitoring of shallow surficial groundwater confirms that N leaching loss is proportionate to application rate and can be substantial under moderate to high N application rates resulting in a direct, substantial economic loss. Results indicate a ‘breakthrough’ response above 0.5-1 kg/ha/day, which also corresponds to the optimum levels in terms of N budget efficiency and pasture productivity. P leaching losses are very low for productive dairy soil types (and mainstream beef soils) with soluble reactive P concentrations below the limit of detection (0.01 mg/L) at 131 of 135 response bore sites on VRC on all sampling dates. This is due to the moderate PRIs of the typical productive dairy soils and means that the total P retention capacity becomes very large when a moderate (or even low) PRI is factored by the soil depth that must be first ‘saturated’ before soluble P becomes evident in the groundwater.

Analysis of groundwater from various depth intervals (385 bores) across the southern Perth Basin indicated no (agriculture-related) N or P contamination of water supply aquifers (such as the Leederville and Yarragadee) under dairy areas. This is due to poor vertical connectivity between surficial aquifers as well as the high probability of P-fixing layers and denitrification potential of waterlogged environments. These data with analysis of published hydrological data, land capability mapping and the soil map unit database, allowed a spatial risk of leaching analysis to be published for the soil units of the southern Perth Basin (Bennett et al. 2007). This analysis also shows that discharge of nutrified groundwater (from the surficial aquifer) to surface streams, drains and ecosystems in dairy areas is very minor and has low environmental risk.

Environmental focus – nutrient runoff

Intensive sampling of surface flow at the paddock and management-unit scale shows that N runoff is poorly related to inputs (intensification) and can be environmentally high even under low intensity (low N) production dairy systems. This means that imposition of N application regulations (as introduced in other countries – mainly for N leaching control) may have little basis for N runoff mitigation for dairy in WA. P runoff can be environmentally high and appears unrelated to dairy management intensity. It is most likely to depend on P status of the soil ‘crust’ meaning that relatively simple application practice recommendations being actively promoted by the Greener Pastures project, such as application based on a target soil test level, could be very effective in reducing P export.

These results highlight that productive agriculture will always have an ‘environmentally excessive’ nutrient footprint at the paddock or management unit scale. An extensive (30 sites, fortnightly) monitoring program within the Vasse catchment confirms that in-stream/drain processes (at primary catchment scale) play a vital role in nutrient runoff mitigation. This means that enhancement of mitigation processes using engineering in primary catchment-scale streams and drains has large potential to mitigate nutrient outflow and should be a focus of ongoing work. Vasse catchment monitoring was designed to provide calibration for the DOW Lascam model (still incomplete) that will predicatively apportion nutrient load to land use and set reduction targets.

Project management, guidance, funding attraction and particularly extension for change have been much easier and effective with industry involvement than for a stand-alone project. Despite some initial reticence, the dairy industry is now openly appreciative of NRM involvement that accurately defines its environmental risks and, where justified, suggests management changes that have a productive basis - rather than NRM that just highlights ‘potential’ environmental risks and can suggest (in isolation) somewhat inappropriate management changes.
References


Modelling reliable runoff from farm scale catchments

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This paper describes the ROSVAR (Runoff Soil-Vegetation-Annual Rainfall) model to estimate annual runoff, and potentially harvestable annual fresh runoff, from small catchments (under 1,000 ha) in the South West.

Climate change, salinity, and increasing competition between production, recreational and environmental uses of runoff mean that water supply security affects most catchments in the south-west of Western Australia. To effectively manage water resources there is need for better information on the runoff-generating potential of catchments.

Current research and modelling are mostly based on larger public water supply catchments. The major factors influencing runoff at this scale are rainfall and vegetation. The influence of soil variability is typically limited, as it tends to average out over the catchment.

Runoff in smaller farm scale catchments is also determined primarily by rainfall and vegetation, but the influence of landscape and soil types is greater as there is less variability. A catchment dominated by clayey or waterlogged soil (or steep slopes) will generate significantly higher runoff than one dominated by well drained sandy or gravelly soils.

DamCat is one model applicable to small catchments. It requires single estimates of runoff exceedence, and does not account for variability within a catchment. DamCat is only designed for assessing individual dams and has limited applicability for broader scaled land-use planning.

**Model description**

The ROSVAR model estimates the volume of runoff that would be exceeded in 90%, 50% and 10% of years. This is done by combining information from 10 mm rainfall isohyets, digital mapping of remnant vegetation; digital soil-landscape data.

The model is based on tables by Ian Laing (Coles and Moore 1998). Laing’s three runoff landform types (A high, B medium, C low runoff) were partitioned into a total of seven landform types including A, AB, B, BC, C, rock outcrop and water bodies. Soil-landscape mapping units are assigned a landform type on the basis of their ability to generate infiltration excess and saturation excess flow.

The infiltration excess index was influenced by a number of factors in the SoilCalc Database. These (and their respective weighting) included:

- Permeability of the surface horizon (Psl) - index values ranged 0-15
- Slope gradient or (Sgl) - index values ranged 0-8
- Surface condition or (Scl) - index values ranged 0-5
- Water repellence (Wrl) - index values ranged 0-3.

The infiltration excess index is calculated by summing these four indices:

\[
\text{Infiltration Excess Index} = Psl + Sgl + Scl + Wrl
\]

The saturation excess index is also influenced by a number of factors in the SoilCalc Database. These (and their respective weighting) included:

- Waterlogging risk (Wgl) - index values ranged 0-20
- Profile permeability (Ppl) - index values ranged 0-15
Depth to permeability contrast (PcI) - index values ranged 0-15
Profile soil water storage (SwI) - index values ranged 0-10
Surface compaction susceptibility (CsI) - index values ranged 0-3.

The saturation excess index is calculated by summing these four indices:

\[ \text{Saturation Excess Index} = WgI + PpI + PcI + SwI + CsI \]

The runoff index for each zone land unit is calculated by summing its infiltration and saturation excess indices.

\[ \text{Runoff Index} = \text{Infiltration Excess Index} + \text{Saturation Excess Index} \]

Zone land units that have a runoff index of 35 or more are assigned landform type A (high runoff). Units with runoff index of 30 to 34 are assigned landform AB (moderately high runoff). Units with runoff index of 20 to 29 are assigned landform B (moderate runoff). Units with runoff index of less than 15 are assigned landform C (low runoff).

The runoff generated from mapped zone units varies depending on rainfall (10 mm increments) and vegetation status (cleared or vegetated). Areas within a catchment of various runoff generations are summed to give a total volume of runoff generated in a catchment for 90% AEP, 50% or 10%. Figure 1 gives a spatial representation of how ROSVAR estimates runoff generated in a catchment.

![Figure 1: Predicted 50% AEP runoff for Lemon's catchment and surrounds](image)

Portions of valley floors that are potentially saline may be assigned to landform type A (high runoff). These areas may contribute significant portions of runoff generated. Runoff may have a high salt loading and is undesirable for freshwater harvesting. For this reason, runoff generated on saline land, or land at risk from salinity can be removed from the estimates.

**Model validation**

Most reliable gauged data available for validation of the model are at the basin and sub-basin scale. Most of these basins are greater than 5000 ha which is well beyond the 1000 ha ROSVAR was designed for.

Preliminary validation in 2005 suggested that the model produced runoff estimates that were exceeded 90% of years when it estimated 90% AEP (see Figure 2).
Figure 2: 90% AEP estimated flows plotted against gauged flow: 90% AEP were exceeded in at least 90% of gauged years

Work by Ben Marillier (unpublished) suggests that $r^2$ for the 10, 50 and 90% AEP was 0.83, 0.78 and 0.73 respectively. More data from catchments occupying less than 1000 ha would help improve the validation.

Application

ROSVAR combined with maps of sub-catchments can be applied across large areas. It may account for more of the variation caused by soil-landscape factors than some regional scaled models. It is suited to estimating yields from small catchments and sub-catchments. The model is being used to investigate the potential of horticulture crops in the woolbelt and has been combined with regional land capability information to improve the identification of high quality agricultural land. Further information is contained in Westrup et al. (2007) and Tille et al. (in prep).

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