Conservation for production: Kings Rocks catchment report

William Oldfield

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CONSERVATION FOR PRODUCTION

Kings Rocks Catchment Report

Prepared for the Kings Rocks Catchment Group by William Oldfield
KING ROCKS
CATCHMENT REPORT

Prepared for the King Rocks Catchment Group by
William Oldfield
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PREFACE

William Oldfield

The aim of this report is to bring together current information on the land and ideas which will provide landholders of the King Rocks catchment group with a basis to make more informed decisions about managing the land. The report contains information on how the landscape was formed, how areas become degraded, what are the present recommended ways of fixing land degradation and what are the most productive means of farming the land.

The recent concerted effort towards more sustainable farming in the decade of Landcare has brought many changes in the way people think and do things. Change is sometimes difficult but it is the way farming has survived in the past and it is also required for the future. I hope this report provides the King Rocks catchment group with a focus for implementation of future projects and land conservation practices.

ACKNOWLEDGEMENTS

Rolf Meeking (Catchment Group Coordinator) - for his commitment to Landcare and the catchment approach and for organising workshop venues and participants.

Kennedy Miller - for his shearing shed at workshops, and groundwork at the top end of the catchment.

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Catchment landholders - for their support and participation in the workshops.

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Ted Lefroy (Research Officer WADA) - for his valuable input on Alley farming.

John Bartle (Research Officer CALM) - for his valuable input on alternative uses for woody plants.

Frank and Joan Meeking - for making valuable observations over the years in the King Rocks area and recording them.
A BRIEF HISTORY OF KING ROCKS

as told by Frank Meeking

This area was originally settled in 1929, having been surveyed in 1927/28. Surveys in those days were very selective.

High, sloping, gravelly land was avoided. The surveyors concentrated on the heavily timbered soils and better type of mallee. Some low-lying land had to be included, as it was nearly impossible to exclude entirely. Blocks averaged between 600 and 1000 hectares, and were soon taken up.

In our case, when any sandy soil type had to be cleared as part of the program, we sowed cereal rye as soon as possible, and disc ploughed the straw in for a fallow year, then planted it to wheat. Admittedly the rye was not very profitable as a grain, but it stopped wind erosion, which we knew well from our previous farming experience in the Victorian Mallee. The resultant wheat crops were always satisfactory.

Clearing for the first 15 years was a slow, manual process in that pre-bulldozer era, with axe, slasher and scrub roller. Most of the original settlers left during the depression of the early 1930s, leaving small areas of clearing. All government proposals were abandoned - the 3500 farm scheme, the Steilman plan for a railway from Brookton to Salmon Gums (surveyed), and the central dam near here, which was to be filled by harnessing several large rocks in the vicinity, to provide a water supply for a big area. Next came World War II, and everything ground to a halt.

With the 1950s came big changes. Farming was becoming more lucrative, and experienced people from other districts were venturing to take on some of the abandoned farms. Bulldozers were being used to develop irrigation in the south-west, and when it was too wet for them to work there, the PWD made them available for clearing and dam sinking in the wheat belt. These processes were completely revolutionised, and farmers seized the opportunity to improve their holdings after years of semi stagnation. PWD graders also built many rooded catchments, a welcome new concept in dam filling.

In the early 1960s, the Government of the day decided it would be a great idea to open up more land in the wheatbelt. It was their proud boast to release a million acres a year, for development. The surveyors moved in, and soon almost every bit of land in the eastern wheatbelt was cut up into blocks of 800-1200 hectares, irrespective of its classifications. These blocks were soon snapped up by aspiring farmers, many of whom had little knowledge of what they were doing, despite having been, seemingly, carefully examined by a Land Board beforehand. The Bulldozers and chains were called in and thousands of hectares cleared on a face.

The late 1950s and early 1960s saw our annual average rainfall of 325 mm exceeded nearly every year with 600 mm in 1963, and several other years very wet. The resultant run-off from vast areas of denuded country which should never have been surveyed, was the beginning of our salt problems.

Efforts have been made to confine the salinity at least to its natural watercourses, by building contour banks with the help of the Department of Agriculture, and WISALTS banks, and planting thousands of trees (with some assistance from Greening Australia). It is an uphill battle and expensive task.

These measures need to be made compulsory for all farms in the catchment system, otherwise the scourge of salt will increase and much valuable land will be lost forever. Funds need to be made available by whatever means, to enable landholders to carry out rehabilitation processes.
GEOLOGY

Soil formation

The present landscape developed on the Yilgarn Block, an ancient rock mass of granite and gneiss over 2500 million years old, and an outlying remnant of the greenstone belt in the north-western corner of the catchment.

Most of the greenstone was derived from basaltic lava. The weathering of the layered sequence of the greenstone belt has produced a valley and slope deposit of red-brown colluvial (by gravity) and alluvial (settling within the soil profile) clay. Soils derived from greenstone are mainly red sandy soils with mottled clay subsoils that have an alkaline to neutral pH.

Soils in the catchment described at the soils workshop that are of the greenstone sequence are: (see soil profile descriptions in Appendix)

- Red loamy clay
- Blue clay
- Brown morrel
- Red-brown silty loam
- Brown clay loam
- Brown loamy clay
- Brown sand over clay.

Granite is composed mainly of quartz 30%, feldspar 60% and mica 10%. Feldspar and mica release potassium, (mostly leached away) iron and aluminium as they decompose to form clay. Quartz is highly resistant to weathering and generally remains unchanged.

Over millennia of weathering the granite rock has produced a thick mantle of soil that consists of a sandy surface over cemented gravel with deep sandy clay beneath. The top of the clay layer has red and yellow mottles owing to iron compounds. Beneath this is white sandy clay called kaolin which is commonly seen beneath breakaways or in dams. Beneath the clay is partly weathered granite rock fragments, saprolite, then granite bedrock.

The pallid zone, kaolin layer, is deepest under the valley floor. Large quantities of soluble salts are stored here. The annual salt input through annual rainfall is 10-20 kg of salt/ha. Accumulation over time has resulted in more than 600 t/ha being stored in the valley floors.

Between the pallid zone and the mottled clay zone the abundance of iron and silica leads to the formation of silcrete. Silcrete is often brought up when digging dams or is sometimes exposed on the surface.

King Rocks is part of the granite bedrock that has been exposed by the erosion of soil into the drainage system nearby (Chin, 1986). This granite dome and others like it are most prominent next to drainage lines because this is where the soil has been eroded the most.

Soils on the granite have developed in a sequence which is repeated according to their position in the landscape. Moving downslope the soil changes progressively from yellow to red, from acidic to alkaline and from deep sand to clay loam over a clay subsoil.

Soils in the catchment described at the soils workshop that formed over the granite/gneiss terrain are:

- Loose shallow gravel
- Sandy gravels
- Acid sands
- Yellow sandplain
- Sand over clay
- Brown sand over clay
- Sandy loam over clay
- Deep pale sand over clay

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GEOLOGICAL UNITS
IN THE KING ROCKS CATCHMENT AREA

Source Information
Roads and topographic features supplied by the Department of Land Administration. Geological features are interpreted from the 1:250 000 Geological Series (Chir R.J.) publication by the Mines Department.

Capture Information
SOILS

As can be seen from the Geology section there are two distinct sets of soil types determined by their geological origin. Descriptions of the various soil types visited during the soil workshop are in the appendix of this report.

Soils are the basic resource of agriculture. Understanding how soils respond and how to conserve them will enable the farmer to develop more efficient and sustainable farming systems. Management of the soils will be discussed in the farming to soil type and following sections as they relate to different aspects of land degradation.

The following is a list of natural limitations of various soils within the catchment.

Table 1. Natural characteristics of soil types that may limit productivity

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Possible limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red loamy clay</td>
<td>Water erosion on steeper slopes</td>
</tr>
<tr>
<td>Loose shallow gravel</td>
<td>Too shallow for lupins and low soil pH in some places and water erosion.</td>
</tr>
<tr>
<td>Blue clay</td>
<td>Hard Setting surface, naturally saline soil prone to waterlogging.</td>
</tr>
<tr>
<td>Brown morrel</td>
<td>Mildly saline, fluffy soil prone to wind erosion, non-wetting, water availability</td>
</tr>
<tr>
<td>Brown clay loam</td>
<td>Waterlogging</td>
</tr>
<tr>
<td>Brown loamy clay</td>
<td>Hard setting surface, soil structure decline with over working.</td>
</tr>
<tr>
<td>Brown sand over clay</td>
<td>Wind erosion and waterlogging.</td>
</tr>
<tr>
<td>Sand over clay</td>
<td>Wind erosion and waterlogging.</td>
</tr>
<tr>
<td>Yellow sandplain</td>
<td>Soil compaction, wind erosion.</td>
</tr>
<tr>
<td>Acid sands</td>
<td>Low pH inducing toxicity effects. Wind erosion.</td>
</tr>
<tr>
<td>Sandy loam over clay</td>
<td>Hard setting surface, soil structure decline. Ponding and waterlogging.</td>
</tr>
<tr>
<td>Sandy gravels</td>
<td>Low nutrient status.</td>
</tr>
<tr>
<td>Deep pale sand over clay</td>
<td>Low nutrient status, waterlogging.</td>
</tr>
</tbody>
</table>
HYDROLOGY

Introduction

King rocks catchment is approximately 620 square kilometres. The main drainage system flows north to south through a wide flat valley that has ill defined drainage in central and northern areas and drops into the salt lake system at the southern end of the catchment near King Rocks.

The central area is under threat of valley floor salinity, because water-tables are between 1.5 and 4 metres from the surface. The problem is compounded by poor drainage, and local run-off accumulates in the salt lakes, swamps and ponds. Only in very wet years does the water flow from one lake to the next. The lakes are part of the Swan-Avon drainage system.

The following list was generated by participants at the Land Conservation workshop. From the list it is very clear that most of the land degradation problems are associated with water.

Table 2. List of land degradation risks that occur in the catchment

<table>
<thead>
<tr>
<th>Problem area</th>
<th>Land degradation risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel ridges</td>
<td>Run-off erosion.</td>
</tr>
<tr>
<td>Gimlet soils</td>
<td>High run-off areas; erosion occurs because hard setting soils are difficult to work and once hard set then produce poor ground cover.</td>
</tr>
<tr>
<td>Breakaways</td>
<td>Pallid zone clays are saline and very fragile. Run-off from breakaway easily erodes this soil.</td>
</tr>
<tr>
<td>Sandplain and gravelly sand seeps</td>
<td>Large areas of the paddock are bare and unproductive owing to waterlogging and saline surface. Recharge to groundwater.</td>
</tr>
<tr>
<td>Sand over clay Duplex soils</td>
<td>Periodic waterlogging - reduced plant growth and water use.</td>
</tr>
<tr>
<td>Ill defined creeks</td>
<td>Water flooding and subsequent waterlogging of flat paddocks in the main valley.</td>
</tr>
<tr>
<td>Crabholes</td>
<td>Collect water and do not grow anything because of water logging.</td>
</tr>
<tr>
<td>Main creeks</td>
<td>Large volumes of water damages fences, roads and erodes waterways.</td>
</tr>
<tr>
<td>Heavy Soils</td>
<td>Soil structure decline. Hard setting.</td>
</tr>
</tbody>
</table>

*Ill defined creek and crabholes, central catchment (Williamsons').*
The following treatments were listed by participants at the workshop. Their current thinking is that this is the way to solve/reduce water problems in the various areas.

Table 3. List of land degradation treatments

<table>
<thead>
<tr>
<th>Problem areas</th>
<th>Current thinking on treatment of these areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel ridges</td>
<td>Level or absorption banks below rocks and where this is no waterway.</td>
</tr>
<tr>
<td></td>
<td>Grade banks or contour working to improve rain infiltration, reduce erosion and control run-off.</td>
</tr>
<tr>
<td></td>
<td>Use natural existing waterways but if degraded find alternative.</td>
</tr>
<tr>
<td>Gimlet soils</td>
<td>Working on the contour with grade banks to prevent run-off eroding other soils.</td>
</tr>
<tr>
<td></td>
<td>Avoid disc ploughs.</td>
</tr>
<tr>
<td></td>
<td>Test gypsum responsiveness, if positive will improve structure, infiltration and workability.</td>
</tr>
<tr>
<td>Breakaways</td>
<td></td>
</tr>
<tr>
<td>Sandplain and gravelly sand seeps</td>
<td>Blocks or strips of trees across the top.</td>
</tr>
<tr>
<td>Sand/clay</td>
<td>Direct drill or minimum till early.</td>
</tr>
<tr>
<td>Duplex soils</td>
<td>Divert run-on flows of water to creek or waterway.</td>
</tr>
<tr>
<td>Ill defined creeks, crabholes, sumps</td>
<td>W-drains to join lower ponded areas and get water away safely.</td>
</tr>
<tr>
<td>and swamps</td>
<td></td>
</tr>
<tr>
<td>Major creek</td>
<td>Address recharge areas upslope, treat them.</td>
</tr>
<tr>
<td></td>
<td>Look into economics of spaced trees.</td>
</tr>
<tr>
<td>Heavy soils</td>
<td>Move sheep off in early winter when little cover and when wet.</td>
</tr>
<tr>
<td></td>
<td>High water usage crops.</td>
</tr>
<tr>
<td></td>
<td>Opportunity cropping on flooded areas.</td>
</tr>
<tr>
<td></td>
<td>Work in with the neighbours.</td>
</tr>
</tbody>
</table>

From this fairly exhaustive list it is clear that many of the answers have come from landholders and that many of the treatments can be done on the farm on an individual basis.

With some of the more costly and less proven land degradation treatments in Table 3, farmers should combine to set up trials, with outside support, to find out more about how they will productively fit into the farming system.

The following sections of the report deal with the water movement within the catchment under two main headings, surface and sub-surface hydrology.
SURFACE WATER MOVEMENT

Surface water movement will be discussed under the two main headings, run-off from the slopes and drainage of the flats.

Run-off

Factors that affect surface water run-off are:

- Catchment area rainfall
- Percentage of cleared area in the catchment (Davies and McFarlane 1987).
  - Soil types;
  - Rainfall intensity;
  - Slope;
  - Soil moisture;
  - Shape of the catchment.
- Cultivation practices
- Surface cover
- Amount of surface compaction
- Surface roughness (Coles and Hauk, 1991)
  - Main creek length and slope;
  - Evaporation.
- Run-off control earthworks (Davies and McFarlane 1988).

Factors marked with a bullet are determined by farm management. Farmers within the catchment have the ability to change these factors to reduce run-off.

The other factors are natural features that cannot be changed but help us to understand particular characteristics of catchments that contribute to the water movement problems.

Farm management and water movement

Clearing

From early accounts and continuing observation it is widely accepted that clearing of the native bushland increases run-off. This is because the bush transpires more soil moisture than annual crops and pastures, it intercepts rainfall reducing the amount that reaches the ground and it slows down the remainder. Approximately 25% of the catchment is Crown land that will remain uncleared. The other 75% is farm land and mostly cleared. Putting all the native bush back, however, would negate the fact that it is farmland.

It is now widely recognised that trees, and perennial woody plants in general, placed strategically can be used to improve farm productivity (see sections on Woody plant production and Alley farming) and reduce land degradation. The cover that might be necessary to achieve these benefits ranges from 10 to 20%. However, this vegetation may not reduce run-off significantly.

Cultivation practices

Working heavy soils two and three times per season, at speeds that smash the soil peds or when it is too dry or too wet can all reduce the soil structure. Heavy soils with poor structure have less pore spaces which limits the rate of infiltration of water and crop growth. Gypsum applied to dispersive soils can improve structure therefore improving crop yields. See Farmnote 57/90 for identifying gypsum responsive soils. Once poorly structured soil has been improved, even if it is not responsive to gypsum, it is essential to prevent further degradation.
Minimum tillage plays an important role in maintaining the soil structure by building up organic matter and leaving residual undissolved gypsum on the surface.

Conserving soil structure will:

- improve internal drainage of the soil, lessening run-off;
- reduce hardsetting of surface;
- lengthen the time the soil is suitable for cultivation; and
- prevent crops haying off prematurely.

Contour cultivation has proved to be an effective way of controlling water erosion in low rainfall areas and can improve yields in the order of 25% depending on soil type. A recent trial conducted by the Narembeen LCD and Department of Agriculture, Merredin, showed that working on the contour and not harrowing i.e. leaving cultivation corrugations improved the yield on light and heavy land by 25%.

Leaving the corrugations increases the surface roughness, allowing rainfall to be held on the surface longer giving it more time to soak in where it can be used by the crop. Cultivating on the contour is one of the best treatments to reduce run-off from cropping country. It does not involve major capital works and does not restrict paddock accessibility.

| Survey level working lines in one paddock on the farm for next season. |
| Contact the community Landcare technician for assistance or advice on correct line spacings. |

Surface cover and compaction
Vegetation cover and management of stock play a major role in reducing run-off and increasing rainfall infiltration.

On sandy loam soils at Avondale Research Station (near Beverley) and Merredin Research Station, trials have shown that there were higher rates of infiltration after direct drilling using a combine compared with conventional cultivation (work up and back, seed).

Soils prone to surface structural degradation can be roughly defined in terms of surface texture (sandy loam to clay) and colour (red, red-brown and grey) (Proffitt 1991). These soils are most vulnerable when wet and a mechanical force applied e.g. trampling by stock. When wet, the surface aggregates are prone to collapse, and when dry tend to set hard. Deferring grazing for up to six weeks from the break of season showed significant increases in infiltration and reduction of run-off (Proffitt 1991). Keeping stock off until the soil is damp to dry will prevent structure decline. Preserving soil structure in the pasture phase can also reduce cultivation in the following cropping year.

| Plan ahead to defer grazing on heaviest soil types when wet for several weeks especially in the first year after cropping. Deferred grazing has a positive effect on the amount of pasture produced during the season. If possible remove stock from heavy land paddocks before rain events. |

Erosion control earthworks
Banks are essential for controlling run-off from high water-shedding areas such as the shallow gravels, gimlet soils, breakaways and shallow duplex soils and for diverting point sources of run-on from other areas. At times when heavy downpours of rain exceed infiltration rates of the soil and when the soil is completely saturated, run-off will occur and needs to be collected in grade banks and diverted to a stable well-grassed waterway.
Soil conservation earthworks should be considered for any high water shedding areas. Community Landcare technicians or Land Conservation Officers at the Department of Agriculture can give advice and assistance on the correct design and layout of earthworks required.

Table 1 illustrates the various structures that are designed for different purposes in the landscape.

King rocks – early settlement water catchment
Table 1. Selection of soil conservation earthworks

<table>
<thead>
<tr>
<th>Structure</th>
<th>Construction machine</th>
<th>Position in landscape</th>
<th>Purpose</th>
<th>Slope</th>
<th>Grade along channel</th>
<th>Channel depth</th>
<th>Channel width</th>
<th>Bank dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade bank</td>
<td>Grader, bulldozer or tractor and plough</td>
<td>Upper to mid-slope</td>
<td>To control surface run-off and erosion</td>
<td>2-15%</td>
<td>0.25%-0.5%</td>
<td>20-30 cm</td>
<td>3-4 m</td>
<td>Height 50-60 cm+</td>
</tr>
<tr>
<td>Level/absorption bank</td>
<td>Grader up to (50 cm high) Bulldozer (+50 cm high)</td>
<td>Upperslope and below breakways, etc.</td>
<td>To control surface run-off and erosion, mainly where there are no safe waterways</td>
<td>Up to 20% or more.</td>
<td>Nil: Pegged on contour. Channel blocks can be used along the channel if seepage areas are present, e.g. sand seams</td>
<td>20-30 cm higher for absorption banks</td>
<td>3-4 m with flat bottom</td>
<td>Usually 90 cm in height settled. Up to 1.2 m settled for large absorption bank</td>
</tr>
<tr>
<td>Reverse banks interceptor</td>
<td>Grader or bulldozer</td>
<td>Mid to lower-slope</td>
<td>To control surface and sub-surface flow</td>
<td>2-6%</td>
<td>0.8-1% and up to 2% at outlet end to exit channel</td>
<td>Maximum 75 cm: to extend 20 cm into clay sub-soil</td>
<td>2.5 m. Best soil duplex with depth to clay 20-50 cm.</td>
<td>2.5 m at base. Height 50 cm settled.</td>
</tr>
<tr>
<td>Diversion bank</td>
<td>Bulldozer</td>
<td>Mid to lower slope</td>
<td>To divert large flows</td>
<td>1-7%</td>
<td>0.2-0.4%</td>
<td>30-60 cm</td>
<td>4-6 m</td>
<td>Height 60-120 cm</td>
</tr>
</tbody>
</table>

Grade or level bank

Absorption bank

Reverse bank seepage interceptor
DRAINAGE OF THE FLAT VALLEYS

Two important distinctions must be made in order to recognise the problem and propose a suitable solution for the valley floors.

Flooding is generally a short term event, i.e. 12 to 48 hours in duration, which produces large volumes of water that has the potential to erode huge gullies, and damage structures in its path such as roads, fences, sheds and earthworks.

Inundation is the water left behind after a flood or is water accumulated in low areas after seasonal rain. Inundation of the low areas causes soils to waterlog, increases infiltration and therefore recharge to the groundwater and degrades soil structure.

Flooding can cause inundation but they are distinctly different problems with different solutions. It is important therefore to determine what the main problems are and which ones are causing the most damage.

Inundation

Waterlogging, that occurs as a result of inundation, can be more of a problem agriculturally than the damage caused by the few floods that may occur, because of the lost production in crops and pastures and the salinisation that results. Waterlogging is not just a problem where water is seen on the surface, waterlogging in the root zone of plants reduces yields significantly. Any efforts to drain away ponded areas are more likely to be economic than methods of controlling major flood peaks (Davies et al. 1988).

Drainage of surface water is best done with shallow channels with wide, flat bottom structures to prevent erosion in the channel and not hinder paddock access. The following earthworks are recommended and are designed such that water can enter from both sides.

Table 2. Relief drains designed to allow water in from both sides.

<table>
<thead>
<tr>
<th>Drain Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-DRAIN (grader)</td>
<td>Used on low slopes. 5% and flats to cope with larger volumes.</td>
</tr>
<tr>
<td>SPOON DRAIN (grader)</td>
<td>Used to drain flats. Generally feed into larger drains. Spoil spread thinly over surface to allow water into the drain.</td>
</tr>
<tr>
<td>SCRAPER DRAIN (scraper)</td>
<td>Used on flats to take larger volumes. Spoil used to fill in waterlogged depressions.</td>
</tr>
</tbody>
</table>

Flooding

Flooding is inevitable in any catchment purely because of the nature of rainstorm events. However, the frequency and intensity of flooding caused by rainstorms can be modified to a certain extent.

Methods of contour working without harrows, grade banks, minimum tillage and vegetative cover, as discussed in the previous section, can reduce surface run-off from small to moderate
storms but may have no effect on run-off from major storms (Davies et al. 1988). Dams, level and absorption banks all act as surface storage providing they are empty at the beginning of a storm.

All flood mitigation structures i.e. absorption banks and WISALT banks should have piped outlets so that they empty out within a couple of days, thereby having the capacity to hold run-off from successive storms and reducing recharge, to groundwater.

Flooding can cause costly damage to farm structures, e.g. house, sheds and fences. Consequently much money and effort is put into dealing with flood water. Three approaches can be taken:

1. Put up with occasional flooding and tidy up the mess afterwards.
2. Construct large earthworks to contain flows and protect farm structures.
3. Re-position sheds and house to a drier more accessible position and replan the fence layout.

Option three is most favourable in the long term as it reduces cost of continual repair of farm structures and maintenance of earthworks. It also allows for more efficient farming of the valley system.

Option two may involve construction of levee banks to prevent water spreading out over the flats and direct it in the main drainage system. Levee bank systems can be effective in containing flood waters but need to be comprehensive and built to an engineering standard (Davies et al. 1988).

If flooding is perceived to be a major cause of damage to farm structures and roads and an erosion hazard then the landholders concerned should combine to request a detailed investigation aimed at reducing the effects of flooding.

Table 3. Leveed waterways designed to confine water flows

<table>
<thead>
<tr>
<th>Description</th>
<th>Cross section (not to scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flat waterway</strong></td>
<td></td>
</tr>
<tr>
<td>Used where run-off requires confining</td>
<td></td>
</tr>
<tr>
<td>or where excavation will expose soils</td>
<td></td>
</tr>
<tr>
<td>that are difficult to vegetate.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Parabolic or dished waterway</strong></td>
<td></td>
</tr>
<tr>
<td>Natural drainage line or constructed</td>
<td></td>
</tr>
<tr>
<td>with levees to confine flow. Pushed</td>
<td></td>
</tr>
<tr>
<td>from outside. Dish depth 15 cm.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Single levee waterway</strong></td>
<td></td>
</tr>
<tr>
<td>Carries flows across slopes or prevents</td>
<td></td>
</tr>
<tr>
<td>flows spilling out across flats.</td>
<td></td>
</tr>
</tbody>
</table>
SUB-SURFACE HYDROLOGY

Catchment water balance
At present there is an imbalance in the water cycle owing to extra recharge to groundwater.

The following figures are based on data collected in a low rainfall (300 mm) wheatbelt catchment (Newdegate) and are used here only as an indication of what is happening with the water balance. Average annual rainfall in King Rocks Catchment is 343 mm.

<table>
<thead>
<tr>
<th>Water balance (mm)</th>
<th>Rainfall</th>
<th>Run-off</th>
<th>Evaporation</th>
<th>Recharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forested</td>
<td>343</td>
<td>6</td>
<td>337</td>
<td>0.01</td>
</tr>
<tr>
<td>Cleared</td>
<td>343</td>
<td>17</td>
<td>306</td>
<td>20</td>
</tr>
</tbody>
</table>

There was some recharge going on before clearing but this miniscule amount was probably leaving the catchment via groundwater movement. Post clearing, the run-off has increased three-fold and the recharge has increased hundreds of times compared with the previous forested state.

It is the extra recharge that has been occurring since clearing that has made the groundwater-table rise. Salinity becomes evident when the groundwater-table gets to within 1.5 metres of the surface. As the groundwater rises salinity will gradually move up the valley.

To prevent the water-table rising, recharge has to be reduced to pre-clearing levels. The challenge is to use up 20 mm more annual rainfall over the whole catchment.

"What falls down must go up!"

Strategies to use up more water at present include higher yielding cropping rotations, early seeded crops, trees and other perennial vegetation on discharge sites and drainage lines.

The natural vegetation developed over centuries of evolution into what is called a climax community where there is a stable rate of biomass production and water use. Water coming into the system equals that going out of it. This is the goal to aim for.

<table>
<thead>
<tr>
<th>Volume of recharge occurring within King Rocks catchment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of catchment: cleared 46,500 ha</td>
</tr>
<tr>
<td>uncleared 15,500 ha</td>
</tr>
<tr>
<td>1 mm/ha = 10 cubic metres</td>
</tr>
<tr>
<td>Cleared 46,500 x 10 m³ x 20 mm = 9,300,000 m³</td>
</tr>
<tr>
<td>Uncleared 15,500 x 10 m³ x 0.01 = 1,550 m³</td>
</tr>
</tbody>
</table>
How many trees would be needed to use up all of the recharge?

Assuming no increase in water use is made by crops and pastures and that a mature tree in the central wheatbelt uses an average of 6 cubic metres of water per year the number of trees needed to use up the recharge would be $9,300,000 + 6 = 1,550,000$ trees.

1,550,000 trees may sound like a lot of trees but spread between 25 farmers, 62,000 each, and planted over twenty years is 3100 trees per farmer per year.

| It is recommended that opportunities for use of perennial vegetation on the farm are found and that revegetation becomes an annual event as part of the long-term strategy to use up more water |

We know roughly how much water we need to use and how much vegetation is required but what opportunities are there for using up the water?

*Dean and Craig Melvin mustering in Alley paddock, Dowerin.*

*The belts of trees are multiples of machinery widths apart.*  
*Tagasaste and Acacia saligna make up the belts and the pasture is a mix of Rhodes grass, annual ryegrass, subterranean clover, brome grass and capeweed.*  
*(See alley farming section, page 32).*
Groundwater recharge is happening all over King Rocks catchment but it is happening faster in certain areas. These are particularly the lighter soil types with plenty of depth which have higher infiltration rates and soil storages.

**Yellow sandplain and sandy gravels**

Rainfall moves quickly downwards through this soil profile and once it is past the root zone it becomes recharge.

The basic aim is to reduce the amount of water that moves past the root zone. There are two main ways to achieve this. The first is to grow early seeded, vigorous crops to take the most advantage of soil moisture.

The second is to grow lupins in rotation because lupins use more water than other crops and pasture. The lupin/cereal rotation is also the most profitable rotation on this soil type. (see Optimal Rotations on Different Soil Types).

**Around granite outcrops**

Rocks create very high run-off and soils around parts of them are very coarse. Rainfall comes off the rock into the soil and moves very rapidly down past the root zone.

Some outcrops in the catchment still have native vegetation around them. The most practical way to control these recharge areas is to fence these areas off and allow natural regeneration. These soils usually regenerate exceptionally well if there is some seed reserve or parent trees still there.

The outcrops that have no vegetation around them should be fenced off and revegetated with the vegetation that grows naturally in these areas (see Granite Rock description in Natural Vegetation section).

**How many trees are needed to use run-off?**

<table>
<thead>
<tr>
<th>Assume:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Run-off from rock is 100% of rainfall</td>
</tr>
<tr>
<td>• Planted trees will transpire 6 m³/tree/year</td>
</tr>
<tr>
<td>• 1 mm/ha = 10 m³</td>
</tr>
<tr>
<td>• Rock area 1 ha, circumference at base 354 m</td>
</tr>
<tr>
<td>• Rainfall at King Rocks is 343 mm</td>
</tr>
<tr>
<td>Run-off = 343 x 1 x 10 = 3430 m³/year</td>
</tr>
</tbody>
</table>

Planted trees around base of rock 3430/6 = 571 trees

If trees are planted every 5 m around the 350 m circumference, eight rows of trees will be needed.
Discharge control

Types of water discharge and guidelines for management

By definition, discharge sites are moisture gaining sites. This gives them great potential for production. Rather than wastelands they are sub irrigated areas of the farm that need tapping into.

It is important to identify why salinity is occurring so that the treatment will be successful. It can be very valuable to dig holes with an auger or borrow a small drilling rig to help to identify:

1. where the water is coming from;
2. how saline the water is;
3. detect if there is any rock under the ground or barriers to water movement.

There are basically five different sorts of discharge areas where water comes to within 2 m of the soil surface to evaporate and cause salinity. These are as follows.

1. Sandplain seep

Rainfall that is not used by crops and pastures on the sandy hill, filters down through the soil profile to a hard layer of cemented laterite or clay. The water then runs downhill on this layer to the base of the hill where the perched water-table comes to within 2 m of the surface capillary action brings the water to the surface causing waterlogging and eventually salinity.

Often sandplain seeps are tolerated if they do not grow any bigger after a few years. However, sandplain seeps also contribute to another problem. They can be high recharge sites to the regional groundwater. The perched water at the base of the sandy hill creates a downward pressure and percolates down through the clay layer.

The diagram below illustrates these two processes.
Management

Some sandplain seeps have been fully reclaimed from several years of lupin/wheat rotation. Alternatively blocks of trees, i.e. 5-10 rows across the top of the seepage site, have been used to reclaim seeps.

A rule of thumb for estimating the number of trees required to use up the water from the seep is 100 trees per hectare of seep area. If the seep is developing use more trees.

Often wetter patches on the sides of the obvious seepage area and other seepage areas will occur on roughly the same elevation because that is where the base of the sandy hills generally occur.

This being the case the blocks of trees above the seeps could be linked with belts of trees and fenced on the change in soil type.

2. Bedrock high and dolerite dyke seep

Both of these type of seeps have a less permeable barrier of rock or clay that prevents sub-surface water movement downslope. Water dams up behind these barriers to within 2 metres of the surface and the salinity and seepage problem begins.

The granite bedrock surface has many natural undulations and where it is close to the surface can perch water and cause seeps.
Dolerite Dykes were formed by intrusions of molten lava in between the cracks of bedrock which fractured during movement of the earth's crust. Because of this they occur in lines across the landscape. The relatively small mass of lava in the cracks between the bedrock cooled quickly to form a very dense rock. The weathered material from this rock, brown sticky clay, allows only slow rates of water movement. Where the dykes have occurred across the slope they can dam water up and cause seepages.

```
perched water
seepage area
dolerite dyke
+ bedrock
```

**Management**

For both types of seep the management is the same. If the immediate seepage area is being eroded by water, control this with a grade bank. If the ground water is not too saline (< 11000 mg/L, 2000 ms/m or 770 gr/gal) the area can be revegetated with salt tolerant trees to lower the perched water-table. Drill to monitor the water level and take a water sample that can be tested for salinity levels so that suitable plant species can be chosen.

Using the recharge calculation at the beginning of this section and substituting in the area of catchment above the seep work out the volume of discharge and required number of trees.

Fence off the area until the trees are established or the seep is reclaimed.

**Change of slope seep**

As the name implies these seeps occur at a change in slope. Because of the slope sub-surface water above the seep area is coming in faster than the slope below the area can remove it. This type of seep usually occurs on duplex soil and in King Rocks catchment is most apparent where the slopes meet the valley floor.
Management is the same as for the rock high seeps. However, because this seep is often associated with duplex soils, farmers should look at the possibility of intercepting the sub-surface flow with interceptor banks and channelling it to a waterway.

As these seeps occur at a change in slope, and often soil type, it is advantageous to manage the soils differently. A belt of trees, double fenced at the change of slope, is recommended to use up water at this moisture gaining site.

*Change of slope seep where the hillside meets the valley floor.*
Valley floor salinity

This type of salinity is the result of the regional water-table being too close to the ground surface. When the water-table comes within 2 m of the surface it begins to be drawn up by capillary rise and evaporates, leaving salts on the soil surface.

In some situations the regional groundwater can find relatively easy routes to the surface. These routes are usually old root channels or less dense areas of clay material compared with the surrounding clays.

1992 has been a particularly wet year and therefore much recharge has been occurring. After an initial investigation by a hydrologist, piezometers have been installed along the valley floor. At the end of winter this year the water-table in a piezometer at Bagshaw Road was measured at 1.97 m, that is, it is within critical depth. The level will go down over summer but this gives an indication that low areas of the valley south of Bagshaw Road are under threat of reduced productivity owing to salinity.

A "Groundwater watch" program should be set up, using existing bores and any others sited as required, to monitor the water levels in the catchment twice a year and objectively assess groundwater movement.

Rolf Meeking reported a 1 ha area of flat paddock that this year became permanently submerged with water. Once the water receded the ponded area had slumped, i.e. it is now lower than the surrounding ground. Without close and detailed observation it is difficult to determine just what happened but the slumping is brought about by too much water.

A possible explanation is that the water-table, which is very close, has mobilised the salts in the soil which have bound up the calcium ions that previously held the soil together. In other words, the sub-soil has lost its structure and therefore collapsed.

An area of paddock that slumped during last years wet season.
Management

As for other discharge sites, the strategy is to drain ponded water with surface drains (see Table 2, p. 11) and to use up as much water as possible.

Using up more water in a valley floor situation will take different forms according to the severity of the site.

**Mildly saline areas** (indicator plants - sea barley grass, woolly clover and annual ryegrass. Salt sensitive plants absent but 100% ground cover). These areas will produce a profitable crop if conditions are favourable i.e. no winter waterlogging.

This land is now seen as the prime site for autumn feed, incorporating saltbush with interrows of annual ryegrass and barley grass. On pure saltbush stands, sheep lose weight whereas on the mixed saltland pasture they maintain weight. Good establishment of saltbush on mildly saline areas requires spraying to remove competition from other species. This will increase costs but the value of this mixed saltland fodder is far greater, because it maintains live weight.

The area of saltland required for autumn grazing will be dependent on the productivity of the saltland and the number of sheep that require feeding. If there is more mildly saline areas than required for autumn feed then another alternative is to plant wide-spaced rows of trees and crop between them, this has been named "Alley Farming".

**Moderately saline areas** (indicator plants - barley grass, annual ryegrass and woolly clover amongst areas of bare ground). These areas will not give a profitable crop.

Moderately saline areas may need protecting with a grade bank if there is surface water erosion. Saltbush will grow well under these conditions but as discussed earlier should be complemented with grasses from an adjacent area to get the benefits whilst autumn grazing. There are also a number of salt tolerant trees that will grow under these conditions.

**Severely saline areas** (indicator plants - curly ryegrass, ice plant, samphire and button weed. However, after grazing these areas are usually bare). The bare areas may need protection from water erosion with a grade bank. Samphire, puccinellia and possibly salt sheoak, *Allocasuarina obesa*, will grow on these areas, providing a cover and using up water.

The productivity of these areas is severely limited which emphasises the need to act early so that more options are available to take advantage of the problem.

For selection of appropriate forage plants for saltland and management of saltland refer to Farmnote No. 32/86 "Saltland management - selecting forage plants for saltland".

-24-
VEGETATION
Existing Plant Associations

The following vegetation description is taken mainly from the Vegetation Survey of Western Australia by J.S. Beard who broadly defines the vegetation of the area into five different associations. The distribution of each type are shown below.

Grouping and naming of plants.

FAMILY A large grouping of plants usually based on detailed flower characteristics. Plant family names with a few exceptions end in "aceae" e.g. Proteaceae.

GENERA A grouping of plants within a family that resemble one another more closely, for example, they have similar leaves or fruits (all hakeas have woody seed cases with two winged seeds inside). The generic name begins with a capital letter.

SPECIES A grouping of plants that have the same characteristics. The specific name is all in lower case.

Where possible in the text the common name has been used to give it some meaning. However, common names for plants vary depending on the person you are talking to or the district you are in. Also common names will often cover a number of different species, for example, broom bush refers to many species of Melaleuca with the same brush type habit.

Salmon gum and gimlet woodlands

The most widespread tree of the wheatbelt, the salmon gum, Eucalyptus salmonophloia, was named botanically by the famous Australian botanist Ferdinand Mueller after the early wheatbelt settler had already given the tree its common name. Since agriculture began forging eastwards past the Darling Range the salmon gum has been regarded as the indicator for good soil. Where Salmon gum and gimlet, E. salubris, occur together it indicates a heavy clay which was then favoured for farming. Morrel, E. longicornis, occurs on fine powdery loams originally blown from the floors of dry salt lakes.

Salmon gums, gimlet, morrel and understorey on heavy soil at northern end of the catchment. The understorey trees include E. sheathiana, E. loxophleba and E. calygoana.
The shrub layer is usually dominated by melaleucas, boree and paupiflora, irregularly scattered large shrubs up to 35 metres in height. Associated smaller shrubs include four species of acacia and others that are of broombush habit with some grasses interspersed amongst them. In the more alkaline areas near salt lakes the saltbush, *Atriplex hymenotheca*, becomes dominant in the shrub layer interspersed with larger shrubs of *Hakea priceii*, quandong (*Santalum accuminatum*) and *Pittosporum phillyraeoides*.

**Teatree scrub**

Teatree scrub or boree replaces woodland under more saline conditions. This type of vegetation is associated with the salt lake system, i.e. south of Lovering road and some of the lower lying lakes just above the salt lake system. Samphire is a part of this system and persists around the edge of the salt pans.

*Melaleuca lateriflora* appears to be dominant in the most saline area. Four other species of *Melaleuca* are noted as well as a few small eucalypts, *E. spathulata* (swamp mallet) and *E. gracilis*.

*Owing to the general rise in the water-table following land clearing in the catchment many boree stands have died or are dying.*

*Salt lake vegetation including patches of swamp mallet.*
Granite rock

Most granite outcrops are covered only by the occasional lichen. Where soil lodges on shoulders and in clefts some small trees may colonise: *Acacia lasiocalyx* and *Allocasuarina huegliana*, sheoak, and shrubs.

Flat and sheltered outcrops may be colonised by the pincushion plant, *Borya nitida*, and surrounded by a dense zone of *Veticordia preissii*.

Fringe communities around the outcrops could include *Allocasuarina huegliana* woodland, *E. loxophleba* woodland, *Acacia lasiocalyx* thicket, *Acacia accuminata*, jam thicket, or mixed thicket with *Melaleuca elliptica*, *Calothamnus quadrifidus*, *Allocasuarina campestris* and *Dodonea attenuata*.

Fringing vegetation on King rocks.

Mallee

In the mallee the larger plants are all eucalypts but there is a dense mixed understorey of shrubs. At any one place an association of four mallees could be expected. *Eucalyptus eremophila* is the commonest and most consistent species and the others tend to vary with location. *E. eremophila* inhabits loamy soils and the name eremophila means desert loving indicating it is found in the drier areas.

The understorey is commonly dominated by one or more species of *Melaleuca* forming an almost continuous layer in which other species are scattered. Other genera in this understorey include *Acacia*, *Callitris*, *Eremophila*, *Gastrolobium*, *Grevillea*, *Hakea*, *Isopogon* and *Leptospermum*.

Mallees usually occur on shallow sands 10-50 cm over clay. There is often a thin cemented layer of sand between the sand and the clay. The surface is neutral to alkaline and the clay subsoil alkaline.

Scrub heath

Usually known as sandplain this association occurs on deep white and yellow sands over gravel or sandy gravels. The shrubs are usually no taller than 2 metres high and no one species is dominant.

Three of the largest plant families *Epacridaceae*, *Myrtaceae* (includes mallee) and *Proteaceae* are well represented. There can be as many as 400 different species in small areas of this heath which is far greater than the forest or woodland formations.
The scrub heath also includes the Wodjil group of *Acacia* spp., *Allocasuarina* spp. and *Hakea* spp. that form dense stands over 2 metres tall on pale yellow sands, sometimes with gravel, which are naturally very acidic. This is the least productive of the wheatbelt soils.

On the ridges of the sandplain, wind has removed the sandy surface to reveal gravelly soils which support dense thickets of tamma, *Allocasuarina* sp.

*Shrub heath on yellow sandplain*

*Tamma thicket on gravelly soil*
RESERVES AND VEGETATION
IN THE KING ROCKS CATCHMENT AREA

Source Information:
Vegetation interpretation from (1988) 1:100 000 aerial photography by Botanical staff of the Spatial Resource Information Group. Reserves from 1:50 000 topo/cadastral maps.

Capture Information:
RESERVES

Before settlement all land in the district was the property of the Crown and as blocks were cleared for farming certain areas were reserved for various public purposes including conservation. Most of them were established for the protection of public property such as water supplies, e.g. springs, soaks and granite rock catchments.

This has had the effect of including within the reserves system most of the scenically interesting granite outcrops and protecting the surrounding flora.

Other areas that were reserved were stands of mallet on the slopes for construction work and stands of beree in the valleys for fenceposts.

Only water reserves exist within the farmed area of the catchment. This means the other vegetation communities are not protected as public property, except for the fragments which exist within road reserves. These reserves do not protect all the vegetation communities and animals within the catchment because these reserves were created for reasons other than conserving biological diversity. The reserves which do exist are dependent on links with other remnants for their continued viability.

Gravel pit regeneration in road reserve near crossroads at Woolcutty wheat bin.

REMnant VEGETATION

In times when economically, every area of the farm is important it may be very hard to see the value in a "common old" piece of mallee heath or acacia thicket.

The scattered patches of remnant vegetation that survive provide the farmer and the wider community with a number of practical and aesthetic benefits as well as maintaining the biological diversity, i.e. the number and variety of living species.

The contributions that individual plant and animal species make to a healthy environment are only just beginning to be understood, however, biological diversity is vital for the maintenance of the life support systems of the world.

The survival of many species of Australian plants and animals depends on habitats provided by areas of remnant vegetation, many of which occur on farmland.

More tangible benefits of remnant vegetation for the farmer are shade and shelter for livestock, water use by the deep rooted plants preventing groundwater rise and the permanent vegetation
cover moderates the affects of strong winds and heavy rainfall. To ensure that these valuable pieces of bush remain an asset they require management just as any other part of the farm.

Management of remnant vegetation on the farm can range from exclusion of stock, to taking an active role in controlling weeds and vermin and planting back the native species and planting vegetation corridors that provide links between them.

It is recommended to fence off areas of remnant vegetation and link them with vegetation corridors where it enhances the farming operation and improves quality of life.

"One of the basic principles of revegetation is to try to use local plants. These plants have evolved to suit local conditions. The local fauna, which has evolved with the plants, will be at home with them and there will be a basis for the many interactions needed to form an ecosystem" (Seabrook, 1991).

Remnant vegetation is affected by salt and rising water-tables and usually it can be seen to be affected before any other indications appear on the surface. Although a lot of these remnant species have evolved varying degrees of salt tolerance, most of them have root systems which developed when the water-tables were significantly lower. There is some evidence to suggest that if these species are replanted (salmon gum in particular) their root systems will adapt to the shallower water-tables (Blake, pers comm).

Remnant vegetation patch (far right) may be linked with road verge (foreground) by linking the strips of bush (centre).

Swamp mallet - salt tolerant mallee indigenous to the King Rocks area.
ALLEY FARMING

Ted Lefroy, Research Officer, Department of Agriculture

The concept is no longer just an idea - an increasing number of farmers are beginning to adopt Alley farming and are finding that benefits to production do occur.

The reasons for yield improvement between alleys include the creation of a higher crop canopy temperature, a reduction in physical damage to leaves, and a reduction in flower abortion and other consequences of heat stress in spring.

Alley Farming has been shown to produce yield increases of 20% in many areas of dryland agriculture in Australia, (Australian Farm Journal p. 64 October 1992), in rainfall zones similar to King Rocks. The draw down on the water-table by wide-spaced rows of trees is also well documented, see Farmnote No. 46/88.

Breakthroughs are also being made with techniques that reduce the cost of establishment to less than $20 a hectare of paddock. This amounts to less than the annual cost of herbicides in wheat growing."

The limited information on the rate at which trees and shrubs use water in this environment suggests a need to replace on average 30-40 stems/ha. If this planting was concentrated into belts 15 metres wide spaced 200 m apart, either along the contour or 90 degrees to prevailing winds, the desired overall population could be achieved while occupying less than 10% of the area (Lefroy 1992).

Alley farming also offers other direct advantages such as eliminating wind erosion, preventing salinity, increasing wildlife habitat and possibly providing a direct source of income from harvesting some of the trees and shrubs planted in the alleys.

Alley paddock on Dean Melvin's property at Dowerin.

The challenge for farmers and researchers is to find the set of plants that will make up the Alley Farming system for their particular conditions. In the valley floors at King Rocks some of the criteria for the plants will be they need to be salt tolerant, high water using without surface feeding roots and suited to heavy soil conditions.

Those interested in the concept of Alley Farming should combine to define their requirements of an Alley Farming system in King Rocks, select suitable species and do a paddock scale demonstration.
PROMISING PRODUCTS DERIVED FROM WOODY PLANTS

John Bartle CALM, Western Australia

It is now widely recognised that trees (or perennial woody plants in general) can be used to remedy land degradation and gain improved productivity in most parts of the low rainfall 'wheat and sheep' agricultural areas of Australia.

Estimates of the amount of tree cover that might be required to achieve these benefits range from 10% to 20%. At an estimated all-up cost (including farm planning, fencing, refilling) of $750/ha this amounts to between $7.5 and $15 billion nationwide.

The motivation for farm tree planting has been Landcare, nature conservation benefits and the enhancement of productivity. These benefits alone are unlikely to be able to fund the cost of tree planting. Furthermore, it is unlikely that contributions from state and Commonwealth Governments will be anywhere near enough to make up the shortfall.

Using a biomass yield of 7.5 tonnes/ha/year the crop of trees required to revegetate low rainfall agricultural areas could have an annual yield of 75 to 150 million tonnes. This vast bulk of flowers, fruits, leaves, bark and wood should be enough to provide the resource base for several large scale industries.

Fodder shrubs offer a relatively easy option to increase commercial perennial woody plant cover because they can be incorporated into conventional grazing practice for the production of meat and wool which have an already established management and marketing infrastructure. Tagasaste and Acacia saligna are already being used extensively.

However, even with a full range of fodder shrubs to choose from, there is still a big potential role for non-fodder species.

Developing new products and industries from other species is more of a challenge. In most cases new knowledge/infrastructure must be built and on-going marketable volumes of product must be generated.

Potential products

Table 1 rates potential products according to criteria which would determine their commercial viability.

The failure of commercially motivated entrepreneurs to develop any new product/species in recent years is probably because these types of developments are too complex, large scale, long term and risky. Also, while the aggregate benefit of a new product may be large the return to the individual developer, financier, investor or grower may be too little to justify the investment.

Brief review of promising prospects

Several promising prospects for development as farm tree products are indicated in Table 1. These will be briefly reviewed to indicate the various types of products, species and industries that could be developed.
1. Eucalyptus oil

Eucalyptus oil is an old established product used internationally in the pharmaceutical industry. The major constituent of eucalyptus oil, cineole, is an excellent solvent and could be a competitive alternative to solvents presently used in various industrial applications.

Many eucalyptus species have high cineole content. Species suitable for a wide range of rainfall and edaphic conditions could be developed.

Modern harvest and steam distillation techniques would need to be developed. Preliminary work done in Western Australia indicates that some 5000 ha of oil eucalypt crop would be required for efficient utilisation of such infrastructure (Allan Barton, pers. comm.).

Leaf oil contents typically range from 2 to 3% (green weight) and yields of 70 kg/ha of oil can be achieved even with genetically unimproved stock. After local extraction, the cost of transport to market would be trivial in relation to the product value of 10 to $12/kg.

2. Tannins

Tannins from eucalypt and acacia species could enjoy a resurgence in market demand. A renewed interest in using natural tanning agents and new uses for tannins in adhesive manufacture will stimulate this interest. Tannin production from brown mallee was formerly a substantial industry in the south-west of Western Australia and was the motivation for the establishment of the Dryandra mallet plantations near Narrogin, some 8000 ha of which were established mostly in the 1940-50s. Similarly a large industry collecting tannin bark from native stands of Acacia mearnsii thrived in the south-east of Australia for several decades.

3. Timber products

There are many species capable of producing timber products in the low rainfall zone. Low value products such as posts and rails for farm use and sawn timber for construction could develop into significant local industries. Value added products such as tool handles, craft wood, laminated wood products such as 'Valwood' for furniture manufacture and reconstituted wood products could be developed for more distant markets. High value specialty wood products such as sandalwood also offer some prospect.

4. Wood energy

Australia has enough low-cost biomass production to rapidly become self-sufficient in renewable solid and liquid fuels if the economic, political and environmental circumstances favoured this outcome. Under current circumstances there are some situations where energy from woody biomass is now or will soon be economically viable.

Firewood is widely used within economic haulage distance of urban and regional centres. Timber mill waste is used for electricity generation at several locations.
Table 1. Woody plant product potential analysis

<table>
<thead>
<tr>
<th>Woody plant part</th>
<th>Product type</th>
<th>Cycle years</th>
<th>Capital cost</th>
<th>Labour cost</th>
<th>$/tonne</th>
<th>$/m³</th>
<th>Radius in km</th>
<th>Value added</th>
<th>Capital cost</th>
<th>Product</th>
<th>Location</th>
<th>Size</th>
<th>Growth potential</th>
<th>Water use</th>
<th>Shelter</th>
<th>Conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flower</td>
<td>Cut flower</td>
<td>1</td>
<td>4-5</td>
<td>5</td>
<td>10³</td>
<td>Open</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Flowers</td>
<td>NI</td>
<td>1-2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Fruits</td>
<td>Fresh</td>
<td>1</td>
<td>4-5</td>
<td>5</td>
<td>10³</td>
<td>100</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>Foods</td>
<td>SNI</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Nuts</td>
<td>1</td>
<td>4-5</td>
<td>4</td>
<td>10⁴</td>
<td>Open</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>Foods</td>
<td>NI</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Seeds</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>10⁵</td>
<td>Open</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>Seed</td>
<td>SNI</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Leaf</td>
<td>Leaf oil</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>10⁴</td>
<td>10³</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>Cineole</td>
<td>SNI</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>2-3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Flowers</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>10³</td>
<td>Open</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Flowers</td>
<td>I</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2-3</td>
<td>3</td>
</tr>
<tr>
<td>Bark</td>
<td>Tannins</td>
<td>10-20</td>
<td>3</td>
<td>2</td>
<td>10³</td>
<td>Open</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>Tannin</td>
<td>SNI</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Cork</td>
<td>20-40</td>
<td>3</td>
<td>3</td>
<td>10⁴</td>
<td>Open</td>
<td>3</td>
<td>2-3</td>
<td>3</td>
<td>Cork</td>
<td>SNI</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Wood</td>
<td>Sandalwood</td>
<td>50-75</td>
<td>3</td>
<td>2</td>
<td>10²</td>
<td>Open</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>Cabinet</td>
<td>I</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Veneer</td>
<td>20-40</td>
<td>3</td>
<td>2</td>
<td>10²</td>
<td>Open</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>Furniture</td>
<td>NI</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Craftwood</td>
<td>20-50</td>
<td>3</td>
<td>2</td>
<td>30</td>
<td>300</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>Cabinet</td>
<td>LSNI</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Reconstit</td>
<td>10-20</td>
<td>3</td>
<td>2</td>
<td>30</td>
<td>300</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>Valwood</td>
<td>SNI</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td>Sawn</td>
<td>15-30</td>
<td>3</td>
<td>2</td>
<td>30</td>
<td>300</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>Lumber</td>
<td>LS</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>2-4</td>
</tr>
<tr>
<td></td>
<td>Board</td>
<td>10-30</td>
<td>3</td>
<td>2</td>
<td>20</td>
<td>200</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>Fibre board</td>
<td>SNI</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2-4</td>
</tr>
<tr>
<td></td>
<td>Pulpwood</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>20</td>
<td>200</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>Pulp</td>
<td>NI</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Liquid fuel</td>
<td>2-20</td>
<td>3</td>
<td>2</td>
<td>20</td>
<td>200</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>Ethanol</td>
<td>LSNI</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Solid fuel</td>
<td>2-20</td>
<td>3</td>
<td>2</td>
<td>20</td>
<td>200</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Firewood</td>
<td>LS</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>2-4</td>
</tr>
</tbody>
</table>

Notes
1. Scaling of costs, value, potential etc. is 1 = small to 5 = large.
2. Transport radius is distance for which transport cost exceeds value of load.
3. Location symbols are L (local), S (state), N (national), I (international).
4. Market size is gauged in relation to potential area of tree planting required to supply product.
5. Varieties dependent on location and conditions.
6. Varieties have not been developed for economic production yet and are in their natural state as found in the bush.
FARMING TO SOIL TYPE
To increase productivity and water use
Steve Curtin - Officer in Charge, Lake Grace

The following section looks at optimal rotations for the different soil groups and includes details of crop water use in relation to reduction of recharge, and the advantages of growing grain legumes compared with pasture legumes. The final section explores the impact on net productivity of cropping low yielding soil types within a paddock.

Optimal rotations on different soil types

The Midas Model (Model of an Integrated Dryland Agricultural System) was used to determine the most economic rotations for the different soil types found in the area. Both lupins and peas were included in the analysis to determine where they would be selected over a pasture:cereal rotation.

Table 1 shows the soil types and the best three rotation options which are selected for each soil type.

Table 1. Optimal rotations

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Preferred option</th>
<th>2nd best option</th>
<th>3rd best option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid sands</td>
<td>PPP</td>
<td>PPC</td>
<td>CCL</td>
</tr>
<tr>
<td>Sandplain soils</td>
<td>CL</td>
<td>CCL</td>
<td>CCC</td>
</tr>
<tr>
<td>Gravelly sands and sandy gravels</td>
<td>CCL</td>
<td>PPC</td>
<td>PPP</td>
</tr>
<tr>
<td>Sand over clay (duplex)</td>
<td>CCL</td>
<td>PPP</td>
<td>CL</td>
</tr>
<tr>
<td>Medium heavy</td>
<td>CCF</td>
<td>CCCF</td>
<td>PPPC</td>
</tr>
<tr>
<td>Heavy clay</td>
<td>PPP</td>
<td>PPC</td>
<td>PCPC</td>
</tr>
<tr>
<td>Heavy clay (gypsum)</td>
<td>CCF</td>
<td>CCCF</td>
<td>PPP</td>
</tr>
</tbody>
</table>

P = Pasture
C = Cereal crop
F = Field peas
L = Lupins

e.g. PPP = Continuous pasture, PPC = two years pasture followed by a cereal crop.

The first option, or most preferred option, is the most profitable selection for that soil type. The second and third options are in order of decreasing profitability.

On the good sandplain soil for example, a cereal:lupin (CL) rotation is the most profitable. Cereal:cereal:lupin (CCL) is next and continuous crop (CCCC) is the least profitable option.

Obviously, the profitability of a particular rotation depends on the prices received for the crops and animals. In Table 1 we assumed wheat at $170/t net pool return with wool at 300c/kg

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greasy. Prices at the end of November 1992 were $176/t for wheat and 330¢/kg h greasy for wool. By varying the prices we are able to see how the rotations for each soil type are affected.

Table 2 shows how rotations on the different soil types are affected by changing commodity prices.

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Wheat - $170/t Wool - 300¢/kg</th>
<th>Wheat - $140/t Wool - 400¢/kg</th>
<th>Wheat $140/t Wool 300¢/kg</th>
<th>Wheat $170/t Wool 400¢/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid sands</td>
<td>PPP</td>
<td>PPP</td>
<td>PPP</td>
<td>PPP</td>
</tr>
<tr>
<td>Sandplain soils</td>
<td>CL</td>
<td>CL</td>
<td>CL</td>
<td>CL</td>
</tr>
<tr>
<td>GS + SG</td>
<td>CCL</td>
<td>CCL</td>
<td>CCL</td>
<td>CCL</td>
</tr>
<tr>
<td>Sand over clay</td>
<td>CCL</td>
<td>CCL</td>
<td>CCL</td>
<td>CCL</td>
</tr>
<tr>
<td>Medium heavy</td>
<td>CCF</td>
<td>PPP</td>
<td>30% PPP</td>
<td>75% PPP</td>
</tr>
<tr>
<td>Heavy clay</td>
<td>PPP</td>
<td>PPP</td>
<td>70% CCF</td>
<td>25% CCF</td>
</tr>
<tr>
<td>Heavy clay (Gypsum)</td>
<td>CCF</td>
<td>CCF</td>
<td>CCF</td>
<td>CCF</td>
</tr>
</tbody>
</table>

It can be seen that some of the rotations selected for different soil types are very robust across a range of commodity prices. The main soil types affected by changing prices are the gravelly sands and the medium heavy soils.

The Midas model suggests that if wool prices are up, then the medium heavy soils are more profitable producing pasture than crops. However, if cropping returns are higher relative to wool returns, then the gravelly sands go into lupins (CCL) and the medium heavy soils go into field peas (CCF). In this way farmers can adjust to changing prices to maintain the most profitable set of rotations for the different soil types. The results from the model also stress the importance of knowing your soil types and what those soils are capable of producing.

**Crop water use**

Crops differ in their ability to use water.

Water use in order of most to least is:

- Lupins
- Barley
- Wheat
- Pasture

This order will vary depending on factors such as plant density, plant vigour, length of growing season and whether the pasture species are annuals or perennials. The determining factor in total water use is dry matter production.

Peas probably use about the same as wheat, and canola is also a high water user, much the same as lupins.
Water use plays an important part in achieving optimal yields from a particular crop. It is also particularly important with regard to catchment management and prevention of excessive groundwater recharge which causes valley floor or hillside salinity.

Efficient water use requires good cropping practices which promote high yielding crops. It is the combination of:

- variety and species;
- soil type;
- time of seeding;
- weed control;
- nutrition.

All the above factors are within our control. They are decisions we make which directly determine our profitability. But they are also decisions which indirectly affect water use and movement in a catchment.

The seasonal factors, such as amount of rainfall and length of growing season, are out of our control but by setting up the crop with the right inputs then we are in more of a position to take advantage of seasonal factors.

Of all the factors above, species selection and soil type selection are the most critical and they are free. They are decisions that don't cost a cent.

It is a waste of time and money trying to overcome a mistake in these two with other costly management inputs such as good nutrition and weed control.

So the right crop on the right soil goes a long way to maximising productivity and promoting good water use.

**Soil type and legumes**

All crops perform differently on different soil types. Soil type selection has a major influence on success or failure of some crops, it is particularly important when growing legume crops such as lupins, peas and legume pastures.

Peas, for example, will yield better than lupins on most soil types. However, the ratio of lupin yield to pea yield is greater on the lighter soils (sandplain and sand over clay) than on the heavier soil (medium heavy and heavy). This is in part because of the effect these soils have on root growth and also the differing ability of these plants to use water on different soil types.

When growing season rainfall is low, the yield advantage of peas over lupins increases. Lupins need to use more water to produce the same yield as peas because they produce more dry matter to achieve that yield. On heavier soils, lupins only use about 90% of the water peas can use but on lighter soils lupins can use 15-30% more.

It follows then that in higher rainfall areas, soil type selection for legumes is not as critical but in low rainfall areas or low rainfall years, soil type selection can make all the difference.

Table 3 shows an estimate of the yields of field peas and lupins expressed as a percentage of wheat for the particular soil type.
Table 3. Field pea and lupin yield for different soils as a percentage of wheat

<table>
<thead>
<tr>
<th>Soil</th>
<th>Field peas</th>
<th>Lupins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good sandplain</td>
<td>50-80</td>
<td>60-110</td>
</tr>
<tr>
<td>Gravelly sands</td>
<td>40-80</td>
<td>50-80</td>
</tr>
<tr>
<td>Sand over clay</td>
<td>80-110</td>
<td>20-100</td>
</tr>
<tr>
<td>Medium heavy</td>
<td>70-110</td>
<td>20-60</td>
</tr>
<tr>
<td>Heavy</td>
<td>70-110</td>
<td>20-50</td>
</tr>
</tbody>
</table>

As can be seen, crop legumes usually yield less than cereals on any one soil type. The table also highlights the soil types on which field peas do better than lupins and vice versa, or which legume is the least risky to grow on a particular soil type.

Despite the legumes yielding less than cereals, the benefits such as nitrogen input, disease levels, high protein seed, good stubble values and higher prices are usually sufficient to economically justify these crops as an important part of any rotation.

Pastures also provide similar benefits to grain legumes but the whole system is both a lower input system with a lower output compared with cropping systems at current wool prices. The downside with a legume pasture is that it usually takes the land out of a high production system for at least two years. This is particularly unprofitable on the better soil types. However, as discussed in the section on Optimal Rotations, pastures do have a place and that place is determined by soil type.

Table 4 gives an indication of where the three main pasture legumes can be grown most successfully and the desired pH range for each pasture type.

Table 4. Pasture legume suitability on different soils

<table>
<thead>
<tr>
<th>Soil</th>
<th>Sub. clover</th>
<th>Medics</th>
<th>Cypress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good sandplain</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Gravelly sands</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Sand over clay</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Medium heavy</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Heavy</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>pH range (CaCl₂)</td>
<td>4.3-7.6</td>
<td>5.2-8.5</td>
<td>5.8-8.9</td>
</tr>
</tbody>
</table>

In the end it is up to you to choose whether you want the low cost system or the high cost system but which ever is chosen you still need to know which rotation is best on each soil type.
Farming to soil type

Farming to soil type simply means grouping together soils which behave the same, grow similar crops and can be managed as one group. This then becomes a management group for which an optimal rotation is planned.

Table 5 shows the groupings of soil types made at the workshop meetings. Logically some of them are similar enough to group together under the new heading of Soil Management Unit. These management units are not too dissimilar to the Optimal Rotations described in Table 1 and so similar assumptions about optimal rotations can be made.

Table 5. King Rocks soil groupings

<table>
<thead>
<tr>
<th>Soil management unit</th>
<th>Legume</th>
<th>Rotation</th>
<th>Soil type</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium to heavy clay soils</td>
<td>Peas</td>
<td>PC</td>
<td>Brown loamy clay</td>
<td>Barley is the preferred cereal on blue clays and morrels</td>
</tr>
<tr>
<td></td>
<td>Medic</td>
<td>CCF</td>
<td>Red loamy clay</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Blue clay</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Brown clay loam</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Morrel</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Red brown silty loam</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Sand over clay (shallow)</td>
<td></td>
</tr>
<tr>
<td>Duplex Sand over clay</td>
<td>Lupins</td>
<td>LCC</td>
<td>Shallow sand over clay</td>
<td>Lupins require greater than 30 cm sand for reliable production. On shallower duplex soils, peas and clover are the preferred legumes in the rotation.</td>
</tr>
<tr>
<td></td>
<td>Peas</td>
<td>CCP</td>
<td>Deep sand over clay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clover</td>
<td>LCP</td>
<td></td>
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<td></td>
<td></td>
<td>CCF</td>
<td></td>
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</tr>
<tr>
<td>Gravel and sandy gravels</td>
<td>Clover</td>
<td>PPC</td>
<td>Loose shallow gravel</td>
<td></td>
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<tr>
<td></td>
<td>Serradella</td>
<td></td>
<td>Acid gravel</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hardsetting yellow sandplain</td>
<td></td>
</tr>
<tr>
<td>Sandplain Soils</td>
<td>Clover</td>
<td>LC or LCC</td>
<td>Yellow sandplain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lupins</td>
<td>CC</td>
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<tr>
<td></td>
<td></td>
<td>LCP</td>
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</tr>
</tbody>
</table>

Abbreviations

P = Pasture
L = Lupins
F = Field peas
C = Cereal
Soil type | Legumes that will grow
---|---
Brown loamy clay | medic, peas
Red loamy clay | medic, peas
Blue clay | medic, peas
Brown clay loam | medic, peas
Morrel | medic (cypress)
Red brown silty loam | medic, peas
Loose shallow gravel | clover, medic (mix)
Yellow sandplain | clover, lupins
Deep sand over clay | lupins, peas*
Acid gravels | clover, serradellas
Sand over clay | clover, lupins, peas*

* Need management to control wind erosion.

Within square paddocks, soil type can vary greatly and long-term farm planning needs to take account of this to make the best use of the resource, because where soil types vary so do crop yields. Redefining paddock boundaries around similar soils or management units is part of the process.

The example below in Tables 6 and 7 show a 100 ha paddock split into three different soil types. Area 1 - 70%; Area 2 - 20%; Area 3 - 10%. The yields, costs and returns at $140/t on farm are worked out for the three areas. Table 6 shows only areas 1 and 2 are profitable at $140/t. Area 3 has lost $100. The bulk of the profit from the paddock comes from the soil type in Area 1.

**Table 6. Variations in profitability across soil types in a 100 ha paddock with wheat at $140/t net**

<table>
<thead>
<tr>
<th>% area of soil type in the paddock</th>
<th>Area 1 70%</th>
<th>Area 2 20%</th>
<th>Area 3 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (t/ha)</td>
<td>1.6</td>
<td>1.2</td>
<td>0.75</td>
</tr>
<tr>
<td>Returns ($/ha)</td>
<td>224</td>
<td>168</td>
<td>105</td>
</tr>
<tr>
<td>Direct costs ($/ha)</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Machinery costs ($/ha)</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Total costs ($/ha)</td>
<td>115</td>
<td>115</td>
<td>115</td>
</tr>
<tr>
<td>Net returns ($/ha)</td>
<td>109</td>
<td>53</td>
<td>10</td>
</tr>
<tr>
<td>Total net returns</td>
<td>$7630</td>
<td>$1060</td>
<td>($100)</td>
</tr>
</tbody>
</table>

**Table 7. Effect on profitability of cropping different % of the paddock**

<table>
<thead>
<tr>
<th>% cropped</th>
<th>Area ha</th>
<th>Total returns</th>
<th>Total costs</th>
<th>Net return</th>
<th>Return ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70%</td>
<td>70</td>
<td>15680</td>
<td>8050</td>
<td>7630</td>
<td>109</td>
</tr>
<tr>
<td>90%</td>
<td>90</td>
<td>19040</td>
<td>10350</td>
<td>8690</td>
<td>96</td>
</tr>
<tr>
<td>100%</td>
<td>100</td>
<td>20090</td>
<td>11500</td>
<td>8590</td>
<td>86</td>
</tr>
</tbody>
</table>

-41-
Table 7 is designed to show what happens if we only crop the better part (70%) of the paddock. In this case we spent $8050 for a return of $7630. If we crop the whole lot (100%) we outlay $11,500 and return $8590 profit. The yield figures and costings may vary but the end result is much the same. Poorer soil types in a paddock are using up valuable cash reserves for very little extra profit. A similar situation can be shown for other combinations of soil types in a paddock. Is it worth it? If wheat prices fall then the situation gets even worse.

This example only looks at wheat but the principle holds for all crops especially those which are more sensitive to a change in soil types than cereals. When prices are high then the effect of those less suitable soil types will be masked, but with low prices they seriously erode the profitability of paddocks.

To maximise productivity, future farm plans should identify the soil types and rotations should be selected which best suit each soil type.

Knowing your soil types and managing them according to agronomic capability, the season and current prices, allows you to better plan your cropping program in the short term and your farm in the long term.
RECOMMENDATIONS

The following recommendations have been drawn from the report in the order they occurred. Page numbers which they came from are included so they may easily be referred to and seen in their context.

1. With some of the more costly and less proven land degradation treatments given in Table 3, farmers should combine to set up trials, with outside support, to find out more about how they will productively fit into the farming system (p. 9).

2. Survey level working lines in one sloping paddock on the farm for next season (p. 11).

3. Plan ahead to defer grazing on heaviest soil types when the soil is wet (p. 11).

4. Soil conservation earthworks should be considered for any high water shedding areas (p. 12).

5. All flood mitigation structures i.e. WISALT banks, absorption banks, etc. should have piped outlets on them so that they empty out within a couple of days thereby having capacity to hold run-off from successive storms and reducing recharge to groundwater (p. 15).

6. If flooding is perceived to be a major cause of damage to farm structures and roads and an erosion hazard then landholders concerned should combine to request a detailed investigation aimed at reducing the effects of flooding (p. 15).

7. It is recommended that opportunities for use of perennial vegetation on the farm are found and that revegetation becomes an annual event as part of the long-term strategy to use up more water (p. 17).

8. Establish a "Groundwater Watch" program to monitor groundwater levels within the catchment twice a year for the next ten years and objectively assess groundwater movement (p. 23).

9. Fence off areas of remnant vegetation and link them with vegetation corridors where it enhances the farming operation and improves quality of life (p. 30).

10. The catchment group should combine to define their requirements of an Alley farming system, select suitable species and plant a paddock scale demonstration (p. 31).

11. To maximise productivity future farm plans should identify the soil types and rotations should be selected that best suit each soil type (p. 41).
How would you like this farming business to look in 20 years time?
References


APPENDIX 1. SOIL DEScriptions

Sandy loam over clay
(Salmon gum soils)

Position in landscape: lower catchment - broad flat valleys:

For all profile diagrams the following key applies.

- **Sand**
- **Loam**
- **Clay**
- **Gravel**

0-10 cm sandy loam, dark colour. pH 5.0 CaCl₂.
10-25 cm loamy clay over sticky grey clay. pH 5.9 CaCl₂.

**General features:**
Sandy loam over a loamy clay at depth.
Hard setting surface.
Root penetration to about 25-30 cm.
Surface neutral tending to slightly alkaline.

**Characteristics:**
Water entry and drainage - reasonably good.
Workability - variable.
Surface soil structure is often degraded leading to poor water entry, ponding and poor workability.
Nutrient status - good.

**Soil conservation:**
Poor soil structure may respond to gypsum and minimum tillage.
Ponding and waterlogging can occur.
A careful opportunistic cropping program using gypsum and minimum tillage must be used to improve surface structure. Deferred stocking to avoid compaction is also important.
Rotations - wheat/wheat/Pea and wheat/medic.
Sandy gravels (hard setting loamy sand over gravel)

Position in landscape: lower catchment - mid to upper slopes:

0-10 cm dark coloured loamy sand. Hard setting. pH 4.5 CaCl₂.

10-20 cm yellow loamy sand. pH 4.0 CaCl₂.

20-35 cm sandy gravel (open gravel).

> 35 cm cemented conglomerate gravel.

General features:
Approximately 30-50 cm of brown to yellow loamy sand over a loose gravel overlying a cemented conglomerate gravel. The surface is neutral tending to slightly acidic at depth.

Characteristics:
Water entry and drainage good.
Workability - good - except where areas of cemented laterites are exposed at surface.
Nutrient status - low.
Water availability - variable - low.

Soil conservation:
Water erosion - sheet and rill erosion potential especially where run-on occurs.
Contour banks and contour working required.
Some potential for wind erosion if surface sand is bared.
Productivity good - wheat, sub-clovers.
- marginal lupin country owing to surface compaction.
Rotations: wheat/wheat/lupin depending on depth and compaction or wheat/wheat/pea.
Deep pale sand over clay

Position in landscape: lower catchment adjoining drainage flats and salt lakes:

![Soil profile diagram]

- 0-10 cm dark sand.
- pH 6.3 CaCl₂.
- 10-30 cm leached pale sand.
- pH 7.5 CaCl₂.
- 30-45 cm sandy medium clay.
- > 45 cm grey medium clay.

General features:
Deep sand overlying a medium sandy clay.
Leached coarse sand.
Positioned along drainage line adjoining salt lakes.
Surface acidic to neutral.

Characteristics:
Water entry good.
Potential for waterlogging.
Nutrient status low.
Soils mildly saline.
Water availability.

Soil conservation:
Waterlogging potential.
Wind erosion potential if bared.
Rotation: wheat/wheat/lupins. Pasture rotation risky owing to potential wind erosion.
Yellow sandplain (deep yellow sand)

Position in landscape: mid to lower catchment on level to gently sloping land:

- 0-10 cm brown sand.
- pH 5.4 (CaCl₂).

- 10-40 cm yellow loamy sand.
- pH 6.2 (CaCl₂).

- > 40 cm yellow light sandy clay loam.
- pH 5.8 (CaCl₂).

General features:
The soil profile is yellow throughout apart from surface darkening. Sand increasing gradually to a sandy clay loam at depth.
Slightly acidic throughout.

Characteristics:
Water entry and drainage - good.
Soil workability good.
Water availability fairly good.

Soil conservation:
Surface compaction by stock leads to high run-off rates in summer storms. Recommend short pasture phase to enhance pasture establishment.
Water erosion - sheet and rill erosion can occur controlled by contour banks and contour working.
Wind erosion potential if sandy surface left bare.
Induced soil acidity potential although soil has a high buffering capacity.
Subsoil compaction potential caused by machinery will reduce yields - soil may be responsive to deep ripping.

Rotations: wheat/wheat/lupins or wheat/lupin and wheat/pasture.
Sand over clay

Position in landscape: mid catchment lower to mid slopes and flats (valley floors):

0-10 cm dark grey sand to loamy sand. (Cultivation depth, organic staining).

10-30 cm pale grey brown sand to loamy clay.

> 30 cm pale medium domed clay.

General features:
The soil profile is a shallow surface sand over a pale sand varying to a sandy loam overlying a medium sandy clay.
Neutral to slightly acidic.
Mallee dominant vegetation.

Characteristics:
Water entry - variable - good.
Workability good except where clays are shallow.
If clays are shallow deep working can incorporate shallow subsoil producing hardsetting surface.

Soil conservation:
Wind erosion potential.
Waterlogging potential.
Brown clay loam (heavy red soil)

Position in landscape upper catchment: mid catchment - broad flat lower slopes:

- 0-25 cm gritty reddish brown sand clay loam pH 6.5
- 25-50 cm brown light sandy clay pH 8.1
- 50 cm+ medium clay increasing with depth

General features:
Hard setting reddish brown sandy clay loam over a brown light sandy clay loam.
Slightly acidic leading to slightly alkaline at depth.
Root penetration to 25 cm.

Characteristics:
Nutrient status - good.
Water entry - average.
Drainage - ?
Workability - can vary - soil structure (surface) may be degraded.

Soil conservation:
May respond to gypsum.
May be prone to local waterlogging.
Brown clay loam (heavy red soil)

Position in landscape: upper catchment - mid catchment lower slopes:

0-25 cm gritty reddish brown sand clay loam.
pH 7.6 electrical conductivity 6.0 ms/m.

25-50 cm brown light sandy clay.
pH 8.1.

50 cm+ medium clay increasing with depth.

General features:
Hard setting reddish brown sandy clay loam over a brown light sandy clay loam.
Slightly alkaline leading to slightly alkaline at depth.
Root penetration to depth.

Characteristics:
Nutrient status - good.
Water entry - good.
Drainage - OK.
Workability - can vary - surface soil structure may be degraded.

Soil conservation:
May respond to gypsum.
May be prone to local waterlogging.
Red brown silty loam
(medium red soil)

Position in landscape: upper catchment - valley floors:

0-20 cm yellowish brown silty loam.
Top 15 cm stained darker.
pH 6.8.

20-50 cm red brown (yellowish) clay loam.
pH 7.2.

50-100 cm brown clay loam.
pH 8.8.

General features:
Non-hard setting brown loam over a light loamy clay.
Neutral tending to alkaline at depth.
Crumbly surface with blocky structure to 50 cm.
Staining at surface indicating good water penetration and high organic matter.
Root penetration to 80 cm.

Characteristics:
Water entry - good.
Water availability - good.
Root penetration - good.
Workability - good.
Nutrient status - good.

Soil conservation:
High potential soil with limited degradation potential.
Waterlogging may occur at confluence.
Water erosion may occur on steeper slopes.
Rotation: wheat/wheat/pea or wheat/pasture/pasture (medic).
Brown morrel (red morrel)

Position in landscape: upper to mid catchment - broad valley flats:

0-45 cm brown silty clay loam, very few nodules or rocks. pH 8.6 electrical conductivity 10.5 ms/m.

> 45 cm brown light clay with some calcareous and greenstone rocks. pH 8.7 electrical conductivity 13.5 ms/m.

General features:
The soil profile consists of a brown silty clay loam surface over a subsoil increasing in texture with depth to a light clay. The profile is highly alkaline and mildly saline. The soil occurs on level to gently sloping areas low in the upper catchment.

Characteristics:
Nutrient status - average.
Workability - good under favourable moisture conditions.
Salinity - sub soils are mildly saline.
Wind erosion - fine textured soils - very vulnerable to wind erosion.
Water availability - limited by osmotic effects of salt content.

Soil conservation:
Wind erosion risk high - caution needed in stubble and pasture management. Loss of topsoil will result in more serious salinity problem because sub soils are inherently saline.
Poor moisture penetration - owing to non wetting and salinity. Stubble incorporation may improve wetting.
Deep ripping may improve surface wetting.
Recommend wheat and barley.
Blue clay
(Sunday country)

Position in landscape: upper catchment - mid to lower slopes:

Surface - hard setting - slaked.
0-20 cm gritty dark greyish brown sandy clay. pH 7.9 electrical conductivity 65.6 ms/m.

20-70 cm light yellowish brown gritty clay. pH 8.9 electrical conductivity 144 ms/m.

General features:
Hard setting sandy clay over dark greyish brown sandy clay. Alkaline at surface tending to more alkaline at depth.
Mild to moderate soil salinity. Root penetration to 20 cm.
Positioned below laterite ridges and breakaways.

Characteristics:
Water entry poor.
Workability poor.
Root penetration poor.
Suffers from waterlogging and salinity.

Soil conservation:
High run-off areas - waterlogging potential, requires contour working and earthworks with potential for reverse seepage interceptor banks.
Potential gypsum responsive soils.
Recommend minimum tillage and early planting to avoid waterlogging damage.
Potential chemical damage with chemical carryover at high pH.
Varieties - barley/wheat/and medics.
Loose shallow gravel

Position in landscape: upper catchment on mid to upper slope:

0-10 cm - dark yellowish brown sandy gravel pH 5.3 CaCl₂.

10-20 cm - yellowish brown sandy gravel, gravel content increasing with depth pH 5.5 CaCl₂.

20-65 cm - loose un cemented gravel.

65 cm - cemented conglomerate gravel.

General features:

Shallow sandy gravel over a gravel and conglomerate. Loose gravel acidic. Water penetration good through profile. May be too shallow for lupins in some places 30 cm+.

Characteristics:


Soil conservation:

Water erosion potential on slopes especially where run-on occurs. Contour working recommended. - earthworks where necessary. Profile too shallow for lupins. Recommend matching varieties with moisture availability using short season varieties.
Red loamy clay
(sticky country)

Position in landscape: upper catchment - upper ridges and slopes:

Surface - non-hardsetting with abundance of small black ironstone nodules.

0-10 cm dark reddish brown loam pH 7.8.

10-30 cm dark red clay loam pH 7.8.

> 30 cm dark red gritty clay loam with layer of decomposing grey material. pH 8.2. Calcareous nodules present.

General features:
Non-hardsetting dark reddish brown loamy clay over a dark red clay loam. Small dark ironstone pebbles on surface. Open surface and profile with good water penetration. High iron content. Root penetration to 45 cm.
Strong aggregation to approximately 20 cm depth. Profile slightly alkaline tending to alkaline.

Characteristics:
Water entry and drainage good.
Water availability good.
Workability good.
Nutrient status good.

Soil conservation:
Water erosion can occur on steeper slopes.
Recommend minimum tillage on contour and earthworks where necessary.
Potential limited on shallow sites (low water holding capacity).
Similar potential to KR 2 - higher potential than KR 1.
Recommend wheat/wheat/pea or wheat/pasture/pasture (medic) rotation.
Brown loamy clay (heavy red soil)

Position in landscape: upper catchment on upper slopes and ridges:

Surface - hardsetting.

0-8 cm brown loamy clay aggregation - cracking
pH 6.8.

8-35 cm - strong brown clay loam pH 7.2.

35-65 cm - reddish yellow clay loam pH 8.1.

65 cm - bottom (90) red brown clay some mottling present
pH 7.8.

General features:

Hard surface setting brown clay loam over a medium clay.
The soil is neutral tending to alkaline at depth.
The staining in the 8-35 cm zone indicates good water penetration and organic matter.
Root penetration to 35 cm.

Characteristics:

Water entry and drainage good.
Water availability good.
Workability - can vary - surface structure readily degraded.
Nutrient status - good.

Soil conservation:

Water erosion can occur on steeper slopes.
Recommend minimum tillage practices, contour working and erosion control earthworks where necessary.
Poor surface soil structure may respond to gypsum and minimum tillage.
Recommend wheat/wheat/pea or wheat/pasture/pasture (medic) rotation.
Brown sand over clay

Position in landscape: mid catchment - lower slopes and valley floor:

0-15 cm medium brown sand.

15-40 cm light brown yellow loamy sand pH 7.0 CaCl₂.

40-90 cm light brown-orange sandy clay pH 8.0 CaCl₂.

General features:
Sand varying in depth from 10-50 cm overlying sandy clay. pH ranging from neutral to alkaline.

Characteristics:
Water entry good.
Workability good.

Soil conservation:
Wind erosion potential.
APPENDIX 2
THE FARM AND CATCHMENT PLANNING PROCESS

A vital part of the farm and catchment planning process is landholder participation. The greater the participation, the greater the information and ideas generated. The participants are the ones that determine what is to be done within the catchment. The forum for participation in the King Rocks catchment and farm planning process has been a series of five workshops which began in mid 1991.

The following is a list of workshops held.

Introduction
- Outline of planning process and mapping with overlays.
- Mapping of natural features.
- Tour of catchment by vehicle and aeroplane.

Soils
- Soil pit tour, discussion on attributes of the soils.
- Soil mapping.

Hydrology
- Talk on anomalies within the catchment and water movement processes.
- Discussion on hydrological features of the catchment.

Land conservation
- Sandplain seep (field walk).
- Soil conservation earthworks for erosion control (talk).
- Trees, their role on the farm (talk).
- Problem areas in the catchment and options for repairing them.

Final
- Discussion on farm improvements (talk - productivity gains with trees, trees for production).
- Mapping of new farm layout.

From discussion in the workshops it was very apparent that what landholders do on their farms has an effect elsewhere in the catchment. The main link between farms is water, both above and below the ground surface. What the landholder does with water run-off and recharge/discharge will affect elsewhere in the catchment.

The problems of water erosion, waterlogging, flooding and salinity are already acknowledged as being reasons for the group forming and beginning the planning process.

The success of arresting these problems in the catchment will depend on the efforts of everyone in the catchment tackling the water problems on their own farm.

The catchment planning process therefore has been going on in parallel with the farm planning workshops. The intent of the workshops was to provide information on the current practices that are widely accepted as sustainable, efficient and productive farming and will reduce land degradation in the catchment.

If you missed the farm planning workshops, information passed on in them is summarised in this report together with the strategies or options for reducing land degradation as was decided upon by those present.

Catchment and farm planning is a continual process of modification as new information comes to hand. Meeting as a group to discuss the new information from implemented projects and outside studies will speed up the modification process and help the group as a whole achieve its goals. It is intended that the King Rocks catchment group meet and discuss the recommendations of this report.