



Department of
Primary Industries and
Regional Development

Research Library

Miscellaneous Publications

Research Publications

8-1993

Byenup Hill catchment report : Carlecatup catchment land conservation district

Justin Hardy

Follow this and additional works at: https://researchlibrary.agric.wa.gov.au/misc_pbns



Part of the [Agronomy and Crop Sciences Commons](#), and the [Botany Commons](#)

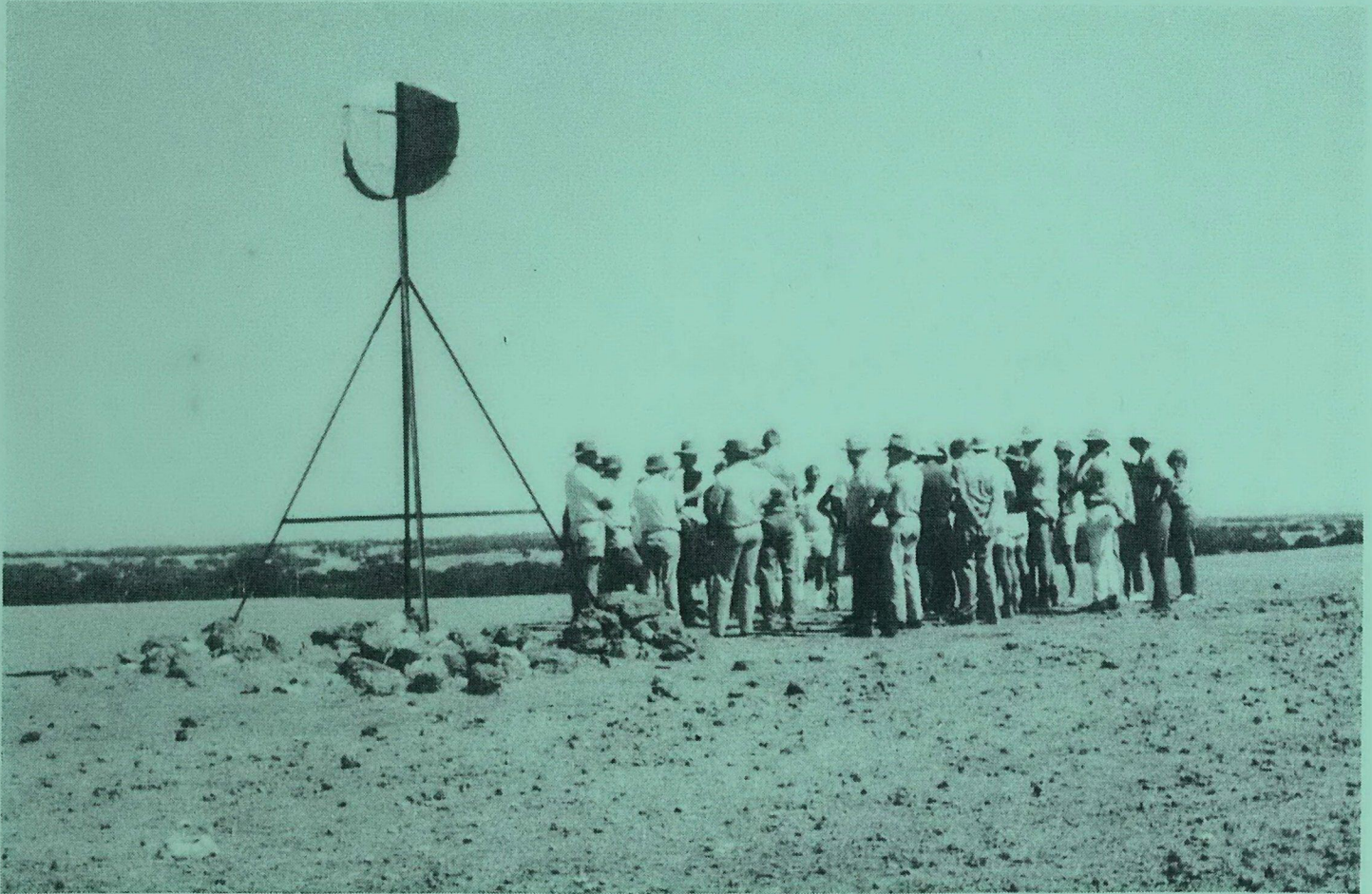
Recommended Citation

Hardy, J. (1993), *Byenup Hill catchment report : Carlecatup catchment land conservation district*. Department of Agriculture and Food, Western Australia, Perth. Report 22/93.

This report is brought to you for free and open access by the Research Publications at Research Library. It has been accepted for inclusion in Miscellaneous Publications by an authorized administrator of Research Library. For more information, please contact jennifer.heathcote@agric.wa.gov.au, sandra.papenfus@agric.wa.gov.au, paul.orange@dpird.wa.gov.au.

Miscellaneous Publication 22/93
ISSN 0725/847X
AUGUST 1993

BYENUP HILL CATCHMENT REPORT



Carlecatup Catchment Land Conservation District

Compiled by:
Justin Hardy
Project Officer
Department of Agriculture
Katanning WA 6317

Table of Contents

Page	Subject	Contributors	
5	Introduction	Justin Hardy, WADA, Katanning	
8	Objectives:	1. Water Balance	
15		MIDAS	
21		2. Land Degradation	
49		3. Nature Conservation	
59		4. Catchment Planning	
65		5. Monitoring	
68		Appendices:	1. Volume Calculations
70			2. Perennials
75			3. Alley Farming
77	4. Saltland Agronomy		
84	5. Wide-spaced Agroforests		
89	6. Pasture Watch		
91	7. Eucalyptus Wandoo: Regeneration in the Wheat Belt		
94	8. Tree Establishment		
97	9. Salinity levels and common EC conversions		

Cover Photograph:

Farmers discuss the significance of hillside seepages and ways to treat them at a catchment level, with Richard George (Dept. of Agriculture, Bunbury) at a field day on the top of Byenup Hill

Byenup Hill Catchment Group

	Members	Farms	Telephone No.
1.	Ian and Sue Palmer Jim and Lucy Palmer	"Cranham"	(098) 25 3090
2.	Alan and Lorelle Goodall	"Korong Vale"	(098) 34 1046
3.	Roger and Marie Bilney	"Forts Valley"	(098) 34 1012
4.	Dave and Lyn Mathwin (David Potts) Graham and Sheila Blacklock	"Barrule" "Tracey's Tree Nursery"	(098) 31 1761 (098) 31 1365
5.	Geoff and Glenis Reinke	"Doodledup"	(098) 25 3082
6.	Mal Anderson (Brown and Betty Parnell)	"Crathie"	(098) 25 3075

Preface

"Getting together for the future"

The Byenup Hill Catchment is situated just west of Graham's Well which was a major watering point for early travellers. The area was first settled around 1890 and some of the names associated with early settlement are Hinchey, Dennis, Bilney, Holding and Gabette. Clearing with axes was a slow process and most of the sheep were run in the bush in areas free from poison bush. A reasonable number of trees were left standing and the last clearing was done in the 1980's. The first signs of salt appeared in the 1930's and advanced with increased clearing.

During the Great Depression, clearing stopped and people survived by growing home produce, bartering, eating kangaroos and 'ground' mutton (rabbits). The rabbit plague was then described as when "paddocks literally moved". Many clumps of trees were killed by the rabbits eating their roots. A major feature of the catchment was the 'polo paddock' on Cranham where matches between Broomehill and Kojonup regularly took place, it was flat and middle distance for both teams. The drop in wildlife numbers has been dramatic, Bodie-rats were last noticed in the 1920's. Numbers of kangaroos, 'brush', possums, curlew, some parrots, eagles, plovers and squeakers have been much reduced. The birdlife chorus has been noted to be much 'quieter'. However mountain duck and 28 parrots have increased.

The six farmers of the Byenup Hill Sub-catchment were fortunate to be offered, in 1989, this opportunity to carry out their catchment plan with outside assistance. By doing so, together with the LCD Committee support, a "model" planning approach would be set up, for the benefit of other Catchment Groups. This was a great encouragement to everyone, and spurred on much activity. We met and established what we considered to be the major problems of the area and then set objectives to help overcome these problems. In achieving these objectives a full range of activities were undertaken.

The objectives and activities come under the following

To get to know the catchment:

- Group meetings with discussions
- Catchment tours
- Flights over the catchment (+ LCD)
- Viewing of the Potter Farm video
- Visit to the North Stirling LCD to look at farm plans and perennial pastures.

To develop the farm plans:

- Purchase of aerial photographs
- Prepare the aerial photographs, "LMUs", "existing works", and "proposed works" on overlays (workshops).
- Prepare and correct farm plans during final digitising on GIS.
- Prepare funding applications for broadacre perennials demonstration (successful 1992).
- Prepare funding application for materials to fence sections of the creeklines (to be confirmed - 1993).

To implement "works" on the ground:

- Plan and implement individual on-farm projects (involving drains, trees, perennials, fencing and establish piezometers).
- Direct seeding of Eucalypts and understorey in a windbreak.
- Tree planting on various sites (annually).
- Fencing to LMUs (ongoing)

To raise awareness and publicise activities:

- Picnic at Yedibirrup Rock
- Articles in the Carlecatup Newsletter/ Kojonup News.
- Reports at LCDC AGMs
- Public launch of catchment/farm plans.

A number of field days and tours were held covering a wide range of topics. We were grateful for the co-operation of all speakers and everyone appreciated the fact that their messages were delivered in an easily understood manner. Participants and field day topics covered were:

- Soil pits and land management units
 - Geology
 - Hydrology
 - Remnant vegetation and native flora and fauna
 - Trees for production
 - Windbreaks
 - Earthworks design and planning
 - Paddock culling, rotations and MIDAS
 - Farm planning, laneways and trees
 - Alternative pastures and shrubs
 - Acid soils
 - Implementing conservation plans
- Justin Hardy, WADA
Mal Graham, CALM, Katanning
Ashley Herbert, WADA,
Richard George, WADA
Richard George and Macushla Casey,
WADA
Peter White, CALM
Richard Moore, CALM
David Bicknell, WADA
William Oldfield, WADA
Paul McKenzie, WADA
Brian Lloyd, WADA
Ted Lefroy, WADA
Fionnula Frost, Perry Dolling
and Tony Clark, WADA
Martin Keen, WADA, Esperance

We each have a digitised farm plan to continue to work towards in the future. These plans are designed to reduce land degradation and improve productivity but flexible enough to allow for modifications as new research data becomes available. A good deal of works have already been implemented, however there is an "open-mindedness" in terms of including new ideas, for instance, five farms in the sub-catchment are to be included in an aerial geological survey with catchments in the adjoining Broomehill LCD. The information gained will either lead to some changes in our existing plans or increase the confidence with which we can implement our current plans and we foresee this as an ongoing process. It is hoped that by also having the plans in a digital form, there will be increased scope to link in with new information such as the geophysics.

In terms of preparing our land for the future generations to farm we have only "hit the tip of the iceberg." It is important we now keep abreast of the research and the developing technologies. That we carry out as much of the research ourselves. Therefore by learning from each other and other groups in the State we can make confident changes in the management of our land.

For farming has largely been a one way activity since clearing, we now must think about "balancing" our demands and improvements to the land.

Finally, it is hoped that other catchment groups can gain some benefits from the work we have done, outlined in this report and plan.

Ian Palmer
Catchment Co-ordinator

Further reading: "History of Barrule" by David Potts (excellent history of people and changes in the catchment)

Acknowledgments

Firstly, I would like to make particular thanks to the following three people.

Ian Palmer, as Co-ordinator for the Byenup Catchment and all his encouragement in maintaining progress, Rosalee McAuliffe for her speedy, efficient typing of the text and many other works; William Oldfield for all his efforts on the details in Objective 2, "Land degradation processes and their treatments in the Byenup Catchment."

Secondly, I would like to thank all the farmers in the Byenup Catchment for their commitment to the plan and hospitality during the project. Also to Marie Bilney and Wayne Zadow for getting the bird lists started. Thanks also go to the Carlecatup Land Conservation District Committee who initiated and supported the project.

Finally, I would like to thank all the people who kindly submitted their time and knowledge to the information already used on the ground by farmers; that is now in the plan; and in this report. These thanks are extended to other members of the office staff at the Katanning Department of Agriculture.

Justin Hardy
Project Officer

The Byenup Hill Sub-catchment was formed as a sub-group of the Carlecatup LCD, the purpose of the catchment was, firstly through the use of extensive farm plans, develop a profile of the catchment, and secondly whilst preparing these plans have a model for future catchment groups involved in farm mapping to follow.

The formation of our group coincided with the beginning of a major down turn in farm profitability which pushed the concept of land conservation programs to the back of most peoples mind. The fact that this group survived the early apathy and has since flourished, is in my mind due in no small way to Justin Hardy.

Justin came to our group via the Katanning Department of Agriculture office from the National Soil Conservation Program. The time, effort and expertise provided by Justin has resulted in a reasonably diverse group of people working quietly together to achieve a catchment plan based on individual farm plans. These farm plans once completed, with various overlays, will I believe take pride of place in ones office and serve as a constant reminder to us that soil conservation does require a plan of action and an achievable goal.

I would like on behalf of the members of the Byenup Sub-catchment group to take this opportunity to thank in particular Justin Hardy for his time and patience and Ian Palmer for his invaluable work as Co-ordinator of our group.

Roger Bilney
(Catchment Group Member)

BYENUP HILL CATCHMENT PLAN

The Report

The following report illustrates a catchment approach to treating land degradation. It supports the map material displaying the individual farm plans and the catchment plan.

The report has three sections:

1. The Introduction Section describes the background, catchment location and an explanation of the steps taken by the group to prepare a catchment plan that integrates the five objectives listed.
2. The Objectives Section describes each of the five objectives in turn. Here a description is included on the future options that will help ensure the desired outcomes are achieved.
3. Finally, the Appendices Section is a compilation of specific subject material; references; and lists of potential resource people.

1. INTRODUCTION

The Byenup Hill Sub-Catchment Group is one of six sub-catchments in the Carlecatup Land Conservation District. It is a unique LCD for the Great Southern because its boundaries coincide with the natural catchment divide of the Carlecatup River which leads into the Arthur River soon to confluence with the Blackwood River.

The Committee chose a model catchment plan approach to treat land degradation. Their intention being to catalyse district wide activities as an outcome of this effort. They invited the participation of the six farmers in the Byenup Hill sub-catchment, chosen primarily because they farm the headwaters of the Carlecatup.

Background

This plan (see objectives) for the Byenup Catchment considers the water use figures of most of the up to date research (CSIRO etc) and combines the following strategies.

1. Establishing high yielding crops and pastures where appropriate
2. Tree planting locations and densities where appropriate
3. Establishing perennial pastures in specific niches
4. Regeneration of native vegetation in strategic recharge areas
5. Drainage systems to reduce the amount of water available for recharge and route fresh water to streams

The sub-catchment is only 3200 hectares, but incorporates six properties. The average annual rainfall is 478 mm (Water Authority Gauging Station on the Cook Road 1975-1992). The main enterprise is wool production with some cropping.

A unique natural feature of the catchment is the Ngopitchup Swamp. Nestled high upslope (380m) still fresh, surrounded by healthy vegetation. The swamp is linked by bush corridor on a closed-off road to Ngopitchup Reserve. This swamp is thought to be a remnant of the old (Quaternary Period) river systems.

The catchment group formed in 1989.

Early get-togethers

The early get togethers of the group clarified the view that changes need to be made to the farming systems in this area to achieve a better water balance, to improve soil stability, fertility, and profitability.

It was recognised that no dramatic land degradation occurred in the Byenup Hill, although not a major problem at the moment, salinity was considered to be the greatest potential threat. However it was considered as undoubtable that the area contributes to the salinity in the lower catchments.

For these reasons it was decided that a farm planning process was first necessary . With outside assistance a catchment perspective and plan of group strategies should be developed too. Finally it was decided a commitment to the long term adoption of the plan was also important.

During the planning process (1989-93) a number of activities have taken place. These have been outlined by Ian Palmer in the Preface, and they have encouraged the participation of everyone in the Carlecatup LCD as well as neighbouring LCDs.

The planning steps

The planning began with the purchase of the aerial photograph enlargements for each farm (1:10,000). The catchment was also covered by an enlargement of 1:15,000 to assist with the catchment plan.

A workshop process continued with the preparation of map overlays. Each farm was divided into land management units based on natural features such as soil type, drainage and vegetation, rather than on the existing boundaries made by people. These land management units could then be managed according to their potential and limitation (potential to degrade).

The farm improvements such as drainage, access roads, revegetation, crop and pasture improvements were considered all together. The preparation of the plans over an extended period of time has allowed for various topics affecting farm improvements to be considered in more depth.

The catchment group through this planning process have helped pioneer an effective approach currently used by other catchments. This includes the maps being digitised in their completed form allowing for increased planning flexibility in the future.



A southern view from an aerial photograph of the catchment, shows recently fenced creeklines and installed grade banks on Barrule.

OBJECTIVES

OBJECTIVE 1:

To maintain the catchment *water balance* by achieving the water use potentials of productive crops, pastures, alternative tree layouts and native plant species.

Background

Peck and Hurle (1973) estimated, that the additional recharge resulting from clearing of eucalypt forests ranged from 23 to 65 mm/year. This is equivalent to 5 to 10% of annual rainfall.

From a hydrological viewpoint, the agricultural plants alone are the major weakness as they are either absent or too small to transpire much water.

Thus to reclaim salinity in the Byenup Catchment and its discharge areas on the lower catchments of the Carlecatup requires special management strategies. Which will lower the groundwater levels by either reducing the amount of rainfall infiltrating into the groundwater or receiving more water from it.

The obvious strategy is to grow plants which evaporate more water than those currently used. Nulsen (1984) showed that recharge can be reduced by up to 50% when a cereal-clover rotation is replaced by a cereal-lupin rotation. He also found that better crop rotations were unable to reduce recharge more consistently than native vegetation.

The ventilated chamber method has been used to measure evaporation (mm/day - See Table 3) of several plant types including:

- tree plantations (Greenwood and Beresford, 1979)
- crops (Nulsen, 1984; Dunin *et al*, 1989, Farrington *et al*, 1992)
- pastures (Nulsen, 1984, Greenwood *et al*, 1985, Farrington *et al*, 1992)
- regenerating forest (Greenwood *et al*, 1982)
- native vegetation (Farrington *et al*, 1992)

This objective for water balance combines strategies of revegetation with agricultural and native plants based on this work.

This combination of strategies preserves the commercial productivity of the catchment without an unrealistic restoration of trees and shrubs. The plan provides plants that can cater for heavy rain that frequently falls at the start of the season, during the season and in summer.

Water Balance

The Byenup Catchment has been treated as a whole farm. This is for two reasons, to illustrate that using water efficiently is allied to making money (profitable crops on suitable LMUs). Secondly the water 'unused' by any profitable enterprises has the potential to cause future degradation (groundwater recharge). Therefore meeting the water-use shortfall with alternative plants must be considered on the LMU's unsuited for high yield cropping.

To examine the water balance in the Byenup Catchment the current water use scenario is estimated in comparison to the water use by the Eucalypt forests before clearing. The plant water-use estimates (evaporation, mm/day) and recharge volumes are tables in the Appendix.

Estimates before clearing and currently (mm/year):

	Rainfall (P)	=	Run-off (R)	+	Evaporation (Et)	+	Groundwater Recharge (Gr)	+	Groundwater Discharge (Gd)
Forested:	478 mm	=	3 mm	+	468 mm	+	2 mm	+	0 mm
Total Cleared:	478 mm	=	10 mm	+	430 mm	+	38 mm	+	0 mm
Wheat only:	478 mm	=	24 mm	+	306 mm	+	148 mm	+	0 mm

The water balance of the catchment is a breakdown of what happens to rainfall. Rainfall is the only input and it needs to be *balanced* by outputs.

The outputs are run-off (R), evapotranspiration (Et) (which includes direct evaporation and transpiration of water by plants) and recharge to groundwater. So prior to clearing the greatest output was evapotranspiration. Run-off accounted for nearly all the remaining output with only negligible outputs to groundwater recharge. Since clearing, the evapotranspiration decreased, run-off increased and infiltration of water beyond the shallow rooted zone of crops and pastures meant recharge to groundwater increased. In the catchment many of the salinity symptoms (seeps and valley salinity) are only just emerging, therefore the implementation of this plan is essential.

This groundwater movement is slow and is limited by the physical material of the catchment (see Objective 2). In terms of solutions, better surface water management has many benefits, particularly to control surface water before it becomes recharge to the groundwater (see Objective 2). However, before considering drainage options, manipulating the total volume of 15.3 million cubic metres of rainfall falling in the catchment per year with high water using plants has been considered by the following strategies.

Outcomes and Actions

I. *Establishing high yielding crops and pastures (see Appendix 1 for details) by:*

- (i) The adoption of 765 hectares of Sandy Gravel soil type (see Table 2, which includes the Gravelly Sandy Duplex and Marri Duplex land management units) to a continuous cropping rotation of cereal-lupin-cereal-canola. (See Catchment map this Strategy is well distributed over the catchment)

It will make profitable use of 348 mm of annual rainfall. ie. the remaining unused water is: 83% of the total volume falling in the catchment.

- (ii) The adoption of 1146.5 hectares of the Sandy Gravel soil types (see Table 2, includes Gravelly Sandy Duplex and Marri Duplex land management units) to a high density subterranean clover based annual pasture. This pasture is in 5 year rotations with the continuous crop in Strategy 1. (See Catchment map, this is also well distributed over the catchment).

This will make a productive use of 288 mm of annual rainfall ie. the remaining unused volume of water now is 61% of the total volume falling in the catchment.

- (iii) The adoption of 726.4 hectares of the Sandy Loam soil type (see Table 2, includes Dolerite and Granite soils) to a high density subterranean clover based annual pasture. This is permanent annual pasture rejuvenated (manipulated or reseeded) every five years. (See Catchment map, the areas are well distributed throughout the catchment).

This will make a productive use of 288 mm of annual rainfall, ie. the remaining unused water now is 47.3% of the total volume falling in the catchment.

2. *Establishing perennial pastures (for details see Appendix 1) by:*

- (i) The adoption of 169.1 hectares of the Marginally Saline Land (see Table 2) to salt tolerant perennial grasses. See catchment map, these plantings are in specific 'niche' environments throughout the catchment.

This will make productive use, (particularly as summer green feed) of 292 mm of annual rainfall. In addition the plants will actively use up stored groundwater, ie. the remaining unused water is now 44% of the total volume falling in the catchment.

- (ii) The adoption of 248.7 hectares of the Waterlogged Soils (see Table 2) to waterlogging tolerant perennial grasses and clovers. See catchment map, these plantings will replace poor quality grass-dominant areas unsuited for inclusion in cropping rotations and are managed separately.

This will make productive use of 292 mm of annual rainfall. In addition the perennials will make use of stored groundwater, ie. the remaining unused water is 39% of the total volume falling in the catchment.

- (iii) The adoption of 8.8 hectares of the Deep Sands to a tagasaste/veldt grass and serradella mix. This will provide summer/autumn feed as well as actively use stored underground water.

This will provide a productive use of 584 mm of annual rainfall, ie. the remaining unused water is now 38% of the total volume falling in the catchment.

3. *Protecting native bushland (see Appendix 1 for details) by:*

The protection of 221.4 hectares of natural corridors and existing native bushland with fencing to allow regeneration of trees and understorey species in the catchment. See Catchment map.

This will make sustained use of 1606 mm of annual rainfall. The additional benefits of native bushland for improving wildlife habitats and biodiversity is considered in Objective 3, ie. the remaining unused water is now 15.7% of the total volume falling in the catchment. (For example this ... equates to 124 hectares of trees (Wandoo) to be further planted. However due to excess stored water it is recommended further plantings to this should take place).

4. *Establishing tree plantations (see Appendix 1 for details) by:*

The adoption of tree plantations on 137 hectares of the catchment for the following purposes and wateruse, (see Catchment map).

- (i) The sustained water-use from 72 hectares of carefully placed 3 row tree windbreaks within cropping and pasture areas; the (*E. maculata*) use 2336 mm of annual rainfall, ie. the remaining unused water is now 4.7% of the total volume falling in the catchment.

- (ii) The sustained water use of 25 hectares of wide-spaced (semi commercial) Eucalypts (in this example *E. camaldulensis*) within permanent pasture on the waterlogged soils they will use 584 mm of annual rainfall, ie. the remaining unused water is now 3.8% of the total volume falling in the catchment.
- (iii) The sustained water use of 20 hectares of salt-tolerant Eucalypt and Acacia strips on Marginally Saline land; they use 584 mm of annual rainfall, ie. the remaining unused water is now 3% of the total volume falling in the catchment.

The sustained water use from dense mid-slope and upper slope tree plantations (semi commercial, eg. *E. saligna*, *E. globulus*)) on 20 hectares of cropping and pasture land.

The remaining unused water is zero. In fact the plants are beginning to utilise soil stored water.

In Summary

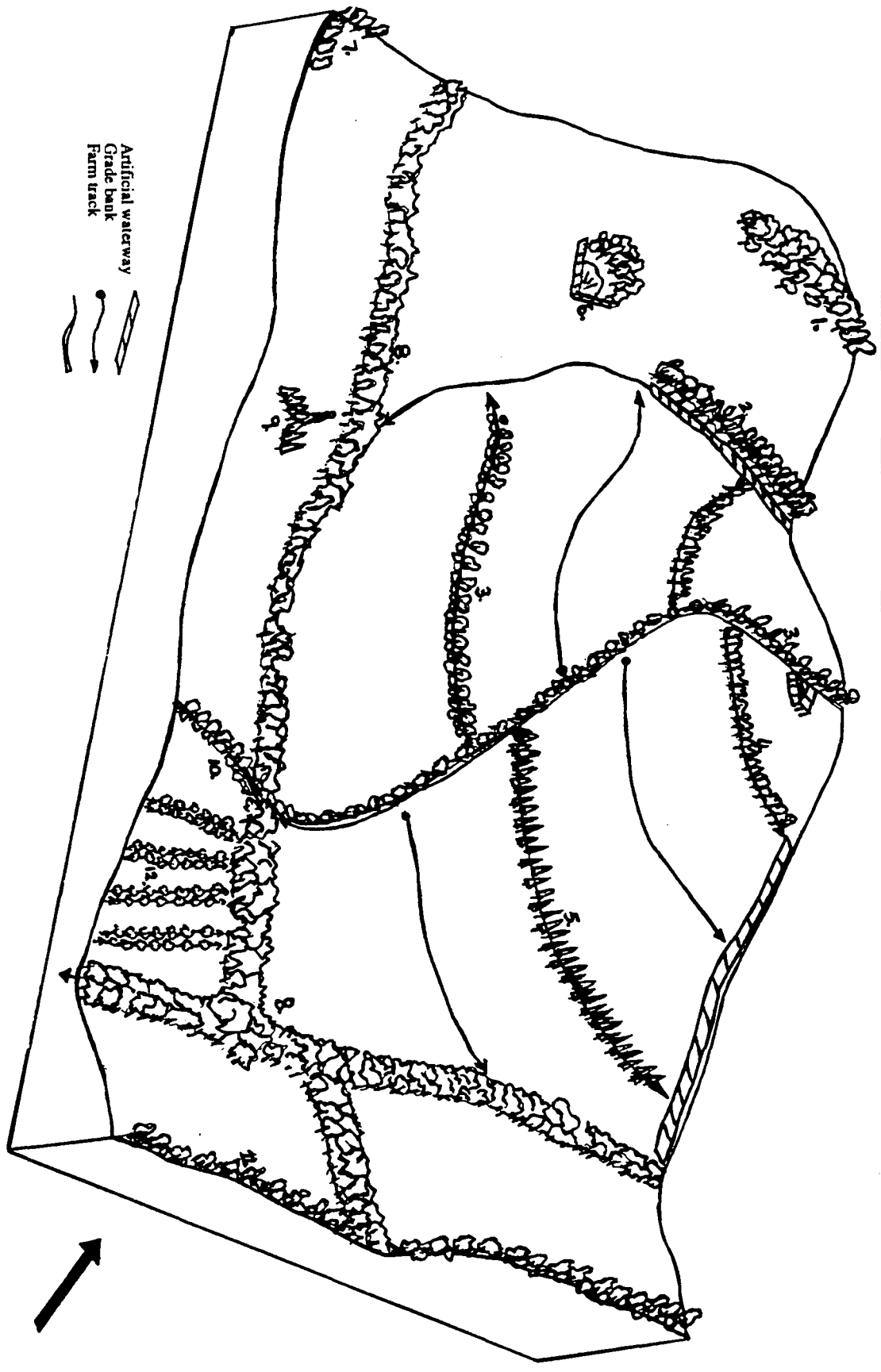
The crop, pasture and revegetation strategies discussed above account for the many functions required from plants to provide a sustainable farming environment. The crops and pasture provide an immediate profit and water use, while the various roles of trees are not considered as a series of separate functions, but as overlapping parts of the whole system. In this holistic way the revegetation approach maximises benefits to both the landholder and the land. For instance the windbreaks have had the effect of using 11% of the annual rainfall. Only 11% of the catchment need be under trees, half by protecting existing bush, and half with new plantings.

'FITTING TREES INTO THE FARM' - the diagram opposite illustrates the various roles (1-12) and overlapping functions of trees.

Location of trees

1. Woodland left on gravelly ridge. Provides shelter for stock, nesting sites for birds and protects top of the hill.
2. Trees planted inside fence of waterway but not on grassed strip which takes the water. Trees also using up sub-surface water which may concentrate in depressions.
3. Trees planted alternately tall and short give good porosity and allow some visibility through the shelterbelt.
4. More uniform shelterbelt planted away from house allows visibility over the top and protects house from prevailing winds. Trees planted alongside banks do not intrude into the farming practise.
5. Pine windbreak for something different. Could have different maintenance requirements e.g. selective pruning of branches to improve porosity.
6. Block of trees to reclaim a hillside seep. Fence may eventually be removed and trees remain as stock shelter.
7. Small areas not lending themselves to production can be put to use.
8. Natural existing vegetation left in the valleys will use up sub-surface water. Particularly important at convergence points in streams.
9. A pattern of trees such as this will provide shelter from winds in all directions.
10. Laneways are good opportunities for windbreaks as they are ideally located along ridgelines and are usually double fenced.
11. Boundary fences are also another opportunity for windbreaks as they are already fenced on one side. Start with the boundaries that will give most windbreaking effect.
12. Wide spaced (40 m), double rowed agroforest to control watertable on flat, low lying LMU and semi commercial sawlog-timber is provided (or other harvestable product).

FITTING TREES INTO THE FARM



Artificial waterway
Grade bank
Farm track

Prevailing wind

In addition:

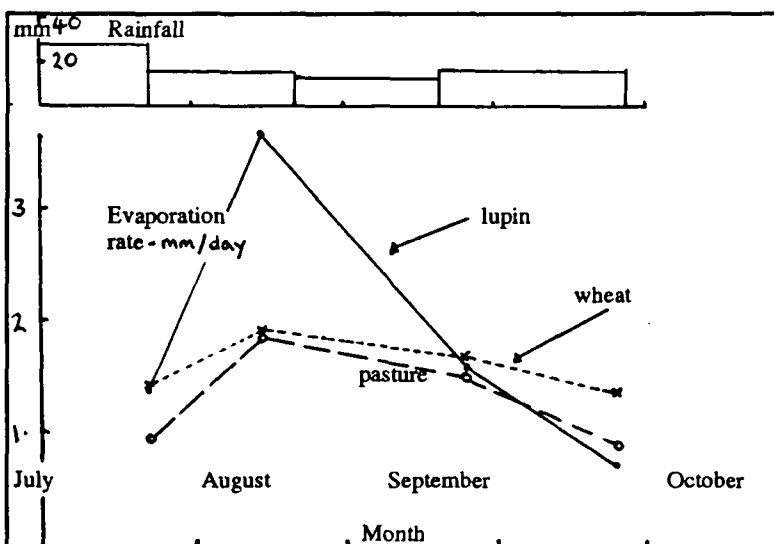
13. A dense planting of trees and shrubs around rock outcrops will reduce the amount of water entering the groundwater system at these typically high water recharge sites.
14. Trees planted around the sheds and silo's will reduce windspeeds and provide shade making working conditions safer, cooler and more comfortable.
15. Trees used creatively will improve aesthetics of the property.
16. Level banks are a known source of water recharge. Trees should be planted along them to use up the water in them.

• **The benefits of the perennial vegetation**

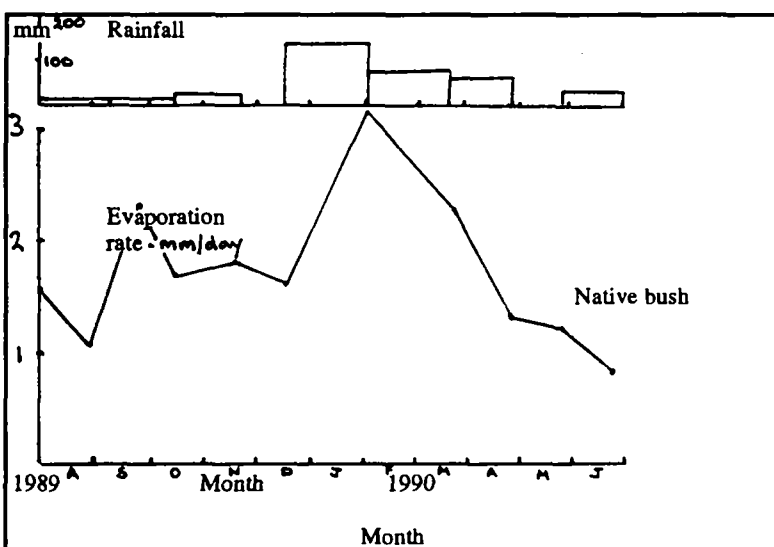
Increased water use by annual crops depends on the distributions of rainfall during the growing season between autumn and spring. If the growing season commences early then crop growth is increased and high water use can be achieved. But the amount of water which can be consumed depends on the incoming rainfall and the crop's ability to extract stored soil water. The graphs below illustrate this response. Here Farrington, *et al* (1992) showed that the greatest contrast between crops was in August, with lupins evaporating 3.6 mm per day, wheat 2.1 mm per day and pasture 27% less than lupins. The greater evaporation rate of lupins over wheat was related to the greater biomass. However they also found that increasing crop density (seeding rates) had a detrimental effect on water output (due to competition for soil moisture, in this case, early in the season).

By contrast, perennial native vegetation (see above Graph 2) is well placed to use water from rainfall outside and at the start of the growing season. The study by Farrington *et al*, 1992 demonstrated native plants were able to transpire continuously through summer and autumn. When a high amount of rainfall unseasonally in summer and autumn the plants responded by greatly increasing their evaporation rate.

Graph 1, rainfall and evaporation rates of lupins, wheat and annual pasture.



Graph 2. Rainfall and evaporation rates of native bush.



As a result there is less potential for recharge into the groundwater beneath perennial vegetation than in the case of the agricultural plants.

Therefore the implementation of the revegetation strategies outlined above in the Byenup Catchment Plan is essential.

While the farm plans are being implemented it is recommended that careful thought is made of these strategies, and of the concept of "fitting trees into the farm." These strategies have been developed for the whole of the catchment. They can be fine-tuned at a farm level as the local knowledge of landscape changes increase and with careful monitoring (see Objective 5). This is becoming evident by the appearance of hillside seeps indicating the catchment has discrete compartments in terms of groundwater storage and movement. It is conceivable that as local knowledge develops to 'balance out' water-use many of these self contained tributaries or "cells" will be treated independently within the catchment. In addition there is more detail on the strategies in the Appendices.

Planning Your Enterprise Mix

With the advent of low wool prices, many farmers are expanding their cropping program to improve cashflow. Gross margins from cropping certainly look attractive relative to margins from sheep, but it is important to also look at the long term effects that extra cropping may have on future profits.

Gross margins for a single year of crop fail to account for interactions that exist between the crop and pasture phases of a rotation and they do not indicate to what extent cropping should be increased to maximise profits.

To overcome the limitations that gross margins have, the Department of Agriculture developed a computer model called MIDAS which stands for "Model of an Integrated Dryland Agricultural System". The objective of this model is to define strategies which optimise annual profits for a 1000 hectare farm with resources typical to those found in the Kojonup/Boyup Brook region. The model provides direction for choosing the best rotations for each soil type, the proportion of farm to crop, and indicates the potential profits that could be made by changing farm strategies.

The High Yield Cropping Strategy

Rotations

Those farmers intending to expand their area of crop have the option of either increasing the length of the cropping phase or increasing the frequency of cropping. For example to achieve 25% crop all paddocks would have to be cropped one year in four. Alternatively, half the paddocks would need to be cropped five years in and five years out while leaving the other half to continuous pasture.

MIDAS shows that increasing the length of cropping is the favoured strategy. There are several reasons for this:

- Frequent cropping reduces pasture productivity, which penalises the grazing enterprise. Leaving some paddocks to continuous pasture results in improved average stocking rates across the whole farm.
- Higher yields can be achieved by concentrating cropping on the better soil types.
- Growing wheat after a grass free break crop such as lupins or canola leads to high yields and a valuable crop.

Table 1: Rotations selected on each soil type

	Marginally Saline Soils	Waterlogged Sands	Deep Sands	Sandy Gravel	Sandy Loam
Most profitable rotation	PPPP	PPPP	PPPP	CLCN PPPP	PPPP
Close alternatives (& \$/ha less profitable)	8PC9(11) 4PC(20)	8PC(11) 4PC(19) 5PCC(24)	8PC(13) 4PC(23) 5PCC(27)	8PC(7) CCLN(11)) 4PC(12)	5PNC(4) 8PC(11) CCLN(11)

Legend:

P	Pasture
C	Cereal (either wheat, barley, or oats) or a hay crop
L	Lupins
F	Field peas
N	Canola

Table 2: Comparison of the LMUs in the Byenup Catchment with MIDAS soil types (*not under remnant bushland)

Byenup Catchment	Total hectares Available*	Comparable MIDAS Model Soil Type	Total area (Ha) (% age of catchment)
Salty Gullies	178.6	Marginally Saline Land	189.1 (5.8%)
Seeps	10.5		
Waterlogged Soils	62.5	Waterlogged Sands	273.7 (8.5%)
Alluvial Soils	2.3		
Flooded Gum Gullies	208.9	Deep Sands	8.8 (0.2%)
Deep Sands	8.8		
Gravelly Sandy Duplex	105.8	Sandy Gravel	1,971.5 (61%)
Marri, Duplex	1,865.7		
Dolerite Soils	222.3	Sandy Loam	770.4 (24%)
Granite Soils	548.1		

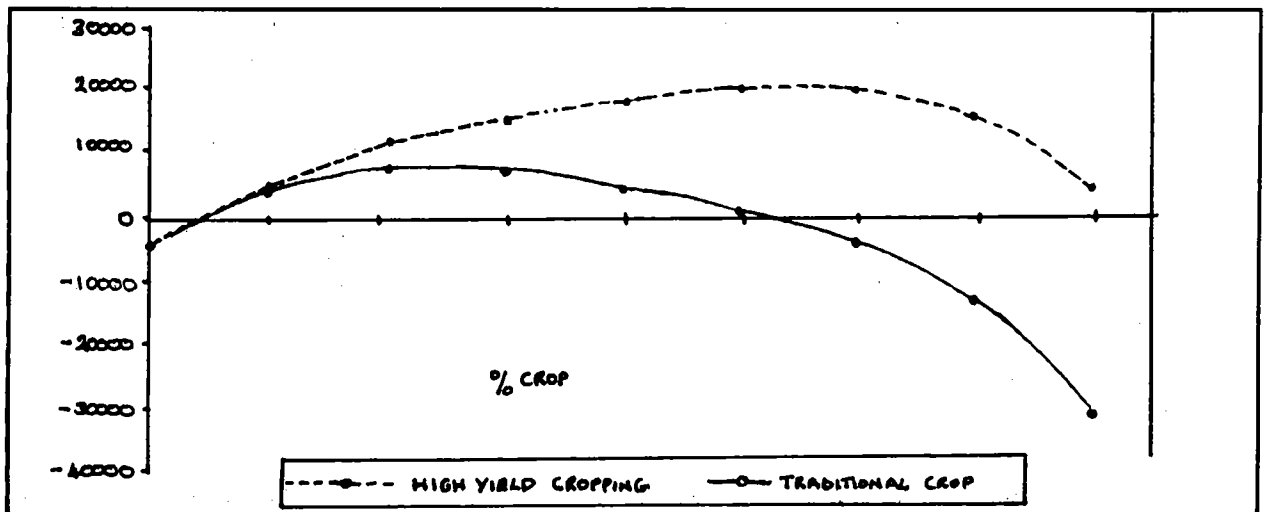
Farm Profit

The graph below shows that at a wool price of 650c/kg (Market Indicator) there is potential to increase annual farm profits by \$12,000 by moving from the traditional strategy of cropping one in five with oats to a strategy of cropping the better soil types continuously with cereals and break crops (lupins and canola). MIDAS shows that even at a wool price of 800c/kg, there are still some rewards to be gained by incorporating continuous cropping into the farm strategy.

Enterprise Mix

Under a traditional cropping strategy MIDAS indicates that 10 to 15% of the farm should be cropped to maximise profits. With a change to continuous cropping, optimal crop area rises to 25% to 30%.

This MIDAS graph shows farm profits being maximised with high yield cropping at approximately 25 to 30% of farm area. A wool price of 650 £/kg (Market Indicator) is assumed.



Other Considerations

While MIDAS defines optimal strategies it does not show us how to implement the changes. Some of the problems with moving into high yield cropping are as follows.

- Lupins and perhaps canola are an integral part of profitable rotations. If these crops have not been grown before, a lot of new skills will need to be learnt.
- It is important to have the machinery and techniques for handling stubble. Straw must be retained to minimise lupin disease and to prevent soil erosion.
- Harvesting canola can present difficulties without access to the correct machinery. Grain can be lost through shedding if harvesting is delayed, and unlike lupins the seed is not picked up by sheep.

The Great Southern model (see appendix) was used to examine the most profitable rotation on each of the major soil classes and also determine which rotations were close alternatives:

Water balance - is it a reality?

The species of plants, the "site selections" for plantings and quantities specified in this plan should continue to be used as a guide at the individual farm level during implementation.

The plant water-use strategies for the catchment case study show inputs balancing with outputs, with room to spare! (Using stored soil moisture).

The total catchment of 3200 hectares has an equivalent of 15.3 million cubic metres of annual rainfall volume. Which is 4,780 cubic metres per hectare - which, in this strategy has been virtually used up! The target extra water to use was 480 cubic metres per hectare per year.

BUDGETING THE CATCHMENT WATER BALANCE

Introduction

"Planning Your Enterprise Mix" on page 15 of the Byenup Hill Catchment Report outlines how MIDAS has been used in this catchment plan. Using MIDAS the optimal enterprise mix on a farm was established (see the MIDAS graph on page 17).

The results have been extrapolated to a catchment, using the Land Management Units and their total areas (hectares) as they were identified and mapped by the farmers.

The model was used to provide a **guide** for the economic optimal area of crop in the catchment. From these areas the amount of water used by crops and annual pasture has been determined (see table below). The deficit in water-use has been "taken-up" with the perennials and trees. However MIDAS makes no consideration for trees and perennials in calculating the economic enterprise mix.

The table shows the breakdown of the water-use by selected plants to achieve a catchment water balance, ie. to 'take-up' the annual rainfall volume of 1.53 million cubic metres).

The "increasing water use" strategies illustrated by this catchment study are dependent on an even distribution of perennial plants. By protecting the existing bush (approximately 5% of the total area) and the establishment of 'new' tree plantings (approximately 5% of the total area) strategically placed with perennials (approximately 12% of the total area) the commercial productivity of the catchment is preserved.

This water balance has been designed for the total catchment from a design point at the culvert on the Graham's Well Road. The strategies have been calculated assuming the catchment is a single groundwater compartment and managed as a single unit ignoring existing farm boundaries. It is recommended that this accounting procedure is used at a more local level (with specific design points) where discrete 'parcels' of land, can be identified, such as sitting behind dolerite dykes. These may be contained and managed on one farm alone or may require a co-operative approach such as on a major tributary. Calculating the water balance is a crucial step for planning to control recharge for every catchment.

Monitoring

It is important to review progress by recording the landuse changes in the catchment over time, such as adding each new hectare of trees, perennials, continuous crop to a data base (such as 'Landkey') each year. This will ensure the focus on optimum water-use remains. In addition, reviewing progress allows new technology and management to supersede and enhance the current strategies.

In summary

The Byenup Hill Catchment plan lists **five objectives** with *outcomes* and *actions* concerning the following topics: Water balance; Conservation works; Nature conservation; Catchment planning and Monitoring. As the catchment environment changes the benefits of having preserved and enhanced the remaining fragments of the natural bushland becomes increasingly apparent. The local diversity increases which improves the resilience of the biological systems to change. The catchment plan has provided an opportunity to begin to model the agricultural systems on the natural ones to help ensure they are sustainable.

Landuse	Total Area Of LMU Groups And The Optimal Water-Use										Total Catch't Water Use (%)	
	Marginally saline land		Waterlogged sands		Deep sand		Sandy gravels		Sandy loams			
	Total Area (ha)	Total Water-use (%)	Total Area (ha)	Total Water-use (%)	Total Area (ha)	Total Water-use (%)	Total Area (ha)	Total Water-use (%)	Total Area (ha)	Total Water-use (%)		
Continuous cropping (*23%)	-	-	-	-	-	-	-	765	18	-	-	18
Annual pasture (*56%)	-	-	-	-	-	-	1146.5	24	678.5	14.7	-	38.7
Perennial pasture (*12%)	130.2	4.3	235.9	7	8.8	1	-	-	-	-	-	12.1
Existing bushland (protected) (*4.9%)	38.9	3.5	12.8	1.1	-	-	48.8	4.24	60.9	7	-	15.84
Windbreaks and upper slopes trees (*2.8%)	-	-	-	-	-	-	61	7.5	31	4.4	-	11.9
Wide-spaced agroforests (trees) (*0.7%)	-	-	25	0.9	-	-	-	-	-	-	-	0.9
Alley farming (trees) (*0.6%)	20	2.9	-	-	-	-	-	-	-	-	-	2.9

Table 3: A summary of plant water use for the agricultural region of W.A. (Evaporation)

Species	Water Use (mm/day)	Soil Type	Rain (mm/yr)	Density LAI	Comments	Reference
<i>E. resinifera</i>	64.1		1400	single tree 30.6 m ² leaf area	8 yr old	Colquhoun <i>et al</i> 1983
<i>E. saligna</i>	42.4		1400	single tree 20.4 m ² leaf area	8 yr old	Colquhoun <i>et al</i> 1983
<i>E. cladocalyx</i>	7.3	gravelly lateritic duncrust	680	816 stems/ha LAI = 3.2	5 yr old upslope position groundwater salinities 320 mS/m	Greenwood <i>et al</i> 1985
<i>E. globulus</i>	7.4	gravelly lateritic duricrust	680	816 stems/ha LAI = 1.0	5 yr old upslope position ground water salinities 320 mS/m	Greenwood <i>et al</i> 1985
<i>E. maculata</i>	6.4	gravelly lateritic duricrust	680	816 stems/ha LAI = 3.4	5 yr old upslope position groundwater salinities 320 mS/m	Greenwood <i>et al</i> 1985
<i>E. globulus</i>	6.1	gravelly lateritic	680	816 stems/ha LAI = 3.4	5 yr old midslope position above seep groundwater salinities 320 mS/m	Greenwood <i>et al</i> 1985
<i>E. leucoxyton</i>	5.0	gravelly lateritic	680	816 stems/ha LAI = 1.3	5 yr old midslope position above seep groundwater salinities 320 mS/m	Greenwood <i>et al</i> 1985
<i>E. wandoo</i>	4.4	gravelly lateritic	680	816 stems/ha LAI = 1.0	5 yr old midslope position above seep groundwater salinities 320 mS/m	Greenwood <i>et al</i> 1979
<i>E. camaldulensis</i>	1.6	deep sandy loam	350	833 stems/ha	4 yr old	Scott <i>et al</i> unpubl.

Table 3 continued.

Species	Water Use (mm/day)	Soil Type	Rain (mm/yr)	Density LAI	Comments	Reference
Tagasaste <i>Chamaecytisus palmensis</i>	1.6	deep sandy loam	350	4000 stems/ha	4yr old cut	Scott <i>et al</i> unpubl.
Tagasaste <i>Chamaecytisus palmensis</i>	1.1	Gravelly	690	600 stems/ha	3 yr old cut	Engel and Scott unpubl.
mixed eucalyptus	>0.7	yellow sandplain	330	200 stems/ha	3 yr old above sandplain seep groundwater salinities 500-1500 mS/m	George 1990
Lupins	2.2	Duplex	350			Farrington <i>et al.</i> , 1992
Wheat	1.8	Duplex	350			Farrington <i>et al</i> 1992
Barley	0.99	Duplex	350			Nulsen <i>et al</i> 1984
Annual Pasture	1.6	Duplex	350			Farrington <i>et al.</i> , 1992
Oats	1.1	Duplex	750			Scott <i>et al.</i> , 1985
Native Heathland	1.5	Duplex	350			Farrington <i>et al.</i> , 1992
Native Shrubland	1.2	Duplex	350			Farrington <i>et al.</i> , 1992
Wandoo/Jarraah bush	4.4	Duplex	770			Greenwood <i>et al.</i> , 1984
Perennial Pastures	0.8	Duplex Clays	450			Person. Comm. Saunders 1993
Lucerne	1.1	Deep sand	450			Nulsen <i>et al</i>] 1985

Table 4: Showing the distribution of land management units (LMU) in the Byenup Catchment.

LMU (total of farm in catchment)	Farms						(Ha) Total
	'Crathie'	'Forts Valley'	'Korong Vale'	'Cranham'	'Dooledup'	'Barrule'	
Dolerite Soils	35.1	76.5	46.4	11	37.8	15.5	222.3
Salty gullies	6.1	53	2.3	10.7	10.9	95.6	178.6
Seeps	1	9.3	0.2	-	-	-	10.5
Deep sands	-	-	8.8	-	-	-	8.8
Gravelly Sandy Duplex	10.2	42.9	19.1	18.8	-	14.8	105.8
Granite Soils	-	453.2	38	2.65	-	54.2	548.1
Marri Duplex	198.6	199.3	408.7	480.1	105.4	473.55	1865.7
Flooded Gum Gullies	5.9	28.1	35.8	66.5	41.9	30.7	208.9
Alluvial Soils	2.3	-	-	-	-	-	2.3
Waterlogged	0.5	13.3	1.8	-	7.9	39	62.5
Total in Catchment	259.7	875.6	561.1	589.75	203.9	723.35	3213.4

In summary

The LMUs have been directly compared to the Soil Types in MIDAS in this section (Table 2). The above (Table 4) shows the distribution of these LMUs in the catchment. Using them, the maximum water-use strategy was established. The components of this strategy are trees, remnant bushland, cropping and annual pastures as described in detail above. The role of perennial pasture is emphasised, further details have been documented in the Appendices. The detailed description of these LMUs has been documented in the following section, Objective 2.

OBJECTIVE 2:

Through careful planning and design of earthworks and windbreaks *control run-off, seepages, and wind erosion* in the catchment during major rainfall and *wind events*.

Outcomes and Actions

1. *To have protected land from water erosion by:*

- Implementing a minimum of 24 km grade banks or reverse interceptor drains.
- Implementing working lines on the grade (where no drains exist) on 2000 ha.
- Maximise plant growth, water use and monitor plant cover on the soil surface throughout the year (especially autumn) for plants.

2. *To have protected erosion points on tracks, dam overflows, and firebreaks by:*

- Identifying sources of the problems.
- Install diversion banks to firebreaks, tracks and road crossings.
- Install overflows, grassed waterways and level sills on dams.
- Utilise and control water run-off where possible eg. dams, re-route excess safely to natural disposal points.

3. *To have protected the low lying land from waterlogging, flooding and recharge from ponded water by:*

- Implementing grade banks and reverse interceptor banks to re-route excess water off the slopes to safe disposal points, dams, drainage lines and waterways.
- Implement relief drains to remove ponded water on flat country (a minimum of 9 km).
- Maximise water-use with trees and perennials (see Objective 1).

4. *To have protected cropping and pastures from wind erosion with 3 row windbreaks (minimum 48 km) by :*

- Identify areas on boundary fences where 3 row windbreaks can be planted.
- Identify areas on the contours (e.g. drains, break in slope) where 3 row windbreaks can be planted eg. on banks.

5. *To have protected hillside seepages and valley salinity by:*

- Target tree plantings around saline seeps (minimum of 20 ha).
- Target tree planting in the upper, mid slopes to intercept groundwater flow to seepages and valley floor (minimum of 45 ha).
- Target tree plantings on the valley floor to control groundwater rise (minimum of 20 ha).

Background

The increased cropping on the Marri duplex land management unit magnifies the need for preventative erosion and waterlogging measures. The tree locations discussed for water use (Objective 1) also serve to protect vulnerable areas of the catchment from wind erosion and provide the additional benefits of shade, shelter and corridors (see Objective 3).

At a number of the early get togethers the group suggested wind erosion is often underestimated. Particularly after major wind events in late summer, for instance there are a number of examples of the effect of cyclones, Alby (1978) and Fifi (1991) as well as less severe seasonal events.

The dramatic benefits of earthwork systems that integrate all the land management units to control excess runoff is well demonstrated on each farm (see Objective 5) where specific projects have been implemented. The care taken planning these works has reduced the risks of water erosion and prevented seasonal waterloggings.

A case study on the economics of drains by Bathgate and Evans 1990 showed that an increase in stocking rate of only 0.4 dry sheep equivalents per hectare was needed for interceptor drains to be profitable. Growing cereals - lupin rotation after draining further increased profits to \$18 per hectare. The projects on each farm in the catchment (pers. comm) have been excellent examples of how drains substantially increase the net return per hectare. The ability to crop added to this profit and has allowed increased flexibility to adapt confidently to the seasonal variations and market forces.

1. Land degradation processes in the Byenup sub-catchment

Soil erosion

Two conditions required for soil erosion to happen are a transport medium (wind or water) and loosened, unprotected soil.

Loosened, unprotected soil is chiefly caused by stock trampling and cultivation. Avoiding this condition by careful management of pastures and reducing tillage will have a large impact on reducing soil erosion.

Wind Erosion is most apparent on exposed hilltops and hill slopes with a westerly aspect. It generally removes only millimetres of soil in sheets over large areas. It is often not obvious except for a build up of the coarser fraction behind fences and vegetation. The finer fraction of the soil, dust, is totally removed in suspension by the wind because it is too light to fall back to the ground.

Loss of the finer fraction of the soil causes the greatest decline in fertility. Wind eroded paddocks have been shown to take 3-5 years to return to their original productivity after a strong wind event.

Preventing wind erosion therefore is decreasing fertiliser inputs and decreasing production losses.

Water Erosion is caused by water movement transporting soil particles. Water begins moving when there is an excess of it on the surface. Excess water occurs either because the soil becomes saturated or the rain is falling faster than the soil can soak it up.

Water erosion takes three forms. Sheet, Rill and Gully erosion. Sheetwater erosion has the same effect as wind erosion only all the soil is washed down slope. Sheet water erosion commonly occurs on shallow sandy topsoils which have poor structure. Being shallow the topsoil does not take long to fill with water. The low cohesiveness of soil particles is soon broken as water begins moving off down slope taking soil with it. Rills generally form where water volume is greater eg. in cultivation lines and low points in the paddock. Rills become gullies once they are greater than 30 cm deep.

Water erosion is sometimes only regarded a problem if it gets to gully proportions and begins to impede the farming operation. As with wind erosion all forms of water erosion lead to production losses and are worthwhile preventing.

Water erosion has an impact downstream also. Lower, in the catchment where water speeds are impeded by lower grades and structures, such as roads, the soil drops out of suspension. Silt deposits block streams and culverts which causes flooding and absorbs large volumes of water which can waterlog existing vegetation and recharge the groundwater aquifer.

Waterlogging

Waterlogging is defined as the saturation of part or all of the root zone of plants. In the agricultural areas of Western Australia, waterlogging has three forms.

- (i) Saturated topsoils commonly occur on sandy duplex soils. These soils have poor internal drainage, low permeability of the subsoils, usually clay, restricts water movement. The topsoils typically have low water holding capacity and can often waterlog just with the rain that falls on them. Waterlogging is often the precursor to salinity and should be treated before vegetation is lost from suspect areas altogether. Waterlogging on shallow duplex soils leads to a saturation excess and water running off. The waterlogged topsoils have low strength and are easily eroded.
- (ii) Saturated soil near the surface occurs on clay soils that have low infiltration capacities and poor external drainage (eg. clay flats). Saturation of the soil surface limits oxygen exchange in the root zone (see diagram 3).
- (iii) Saturation of the soils which occur in seeps and saline areas. The excess water in these situations comes from sub-surface flows or the groundwater table and is often saline.

Waterlogging is often the precursor to salinity and should be treated before vegetation is lost from suspect areas altogether.

Valley floor salinity



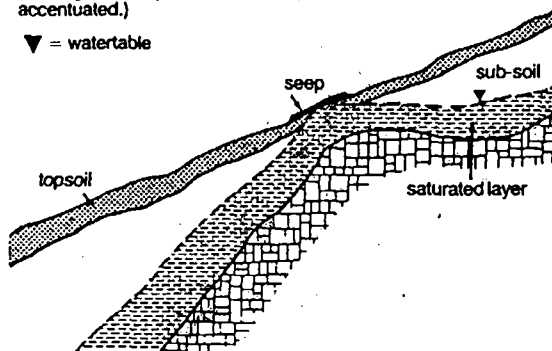
Hillside Seeps begin as waterlogged areas and often develop into salt patches. Water comes in from sub-surface flow in hillside seeps, rather than directly from rainfall. The different kinds of hillside seeps are defined in the *Journal of Agriculture* No. 4, 1985, pp 128-129.

Diagram 1. The four causes of hillside seepages in the landscape.

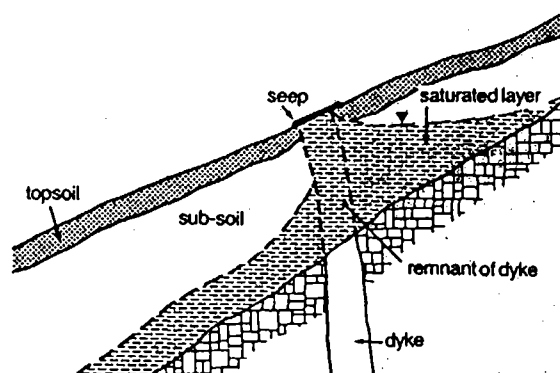
Seep caused by a bedrock high

(In all figures, the position of the seep has been accentuated.)

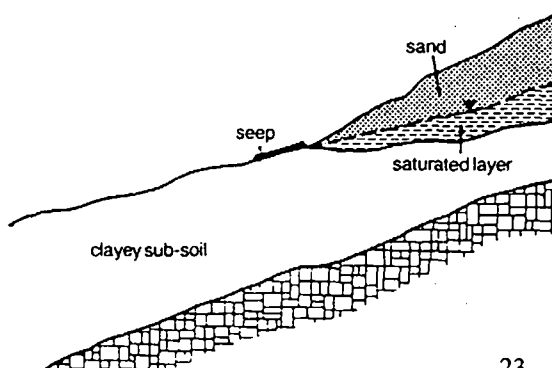
▼ = watertable



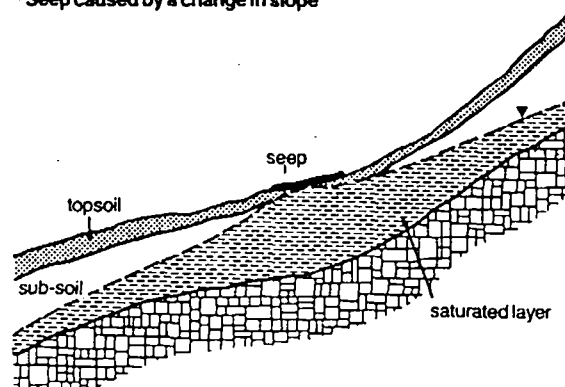
Seep caused by a dyke



Seep at the base of a sandy rise



Seep caused by a change in slope



Hillside seeps in the Byenup catchment commonly take the form of dolerite dykes, clay and bedrock highs. The dykes, clay and bedrock cause water in the soil profile to dam up and cause waterlogging and seepages at the surface.

Opportunities for using up the sub-surface water through use of deep rooted perennial grasses and trees should be sought as hillside seeps are a significant problem in the catchment

Salinity

Most of the salt in wheatbelt soils has come from the sea. Over geological time small amounts of salt (40 kg/ha) have been coming in with the rainfall and accumulating in the soils. Under the present system of agriculture water use has not equalled the amount of water falling on the ground resulting in rising ground watertables. The rising ground water brings with it the dissolved salts. Once the salty ground water rises to within two metres of the surface it begins to have an effect on plant growth. By the time the groundwater table reaches the surface the ground becomes totally bare because normal plants will not grow under waterlogged, saline conditions.

As can be seen by the above description salinity is generally associated with rising water tables therefore water use is the key to controlling salinity.

An exception to this is in sandy soils which have good internal drainage. The salts that come in with the rainfall are unable to concentrate to levels which inhibit plant growth because sands leach out very quickly. Sandplain sites can waterlog and if they do they generally remain fresh. They can be used for farm water supply and Sandplain seeps are often made into soaks or pumped from a bore to irrigate the farm.

In summary steps to control hillside seeps:

Determine type of seep and where water is coming from ie. is the water perched on shallow clay where it is accessible by deep rooted perennials or interceptor bank

or

Is it coming from deeper in which case a small block of trees would be more appropriate.



Valley salinity in the lower catchments.

2. LAND CONSERVATION CONSIDERATIONS BY SOIL UNIT

MARRI SANDY DUPLEX LAND MANAGEMENT UNIT

IDENTIFICATION

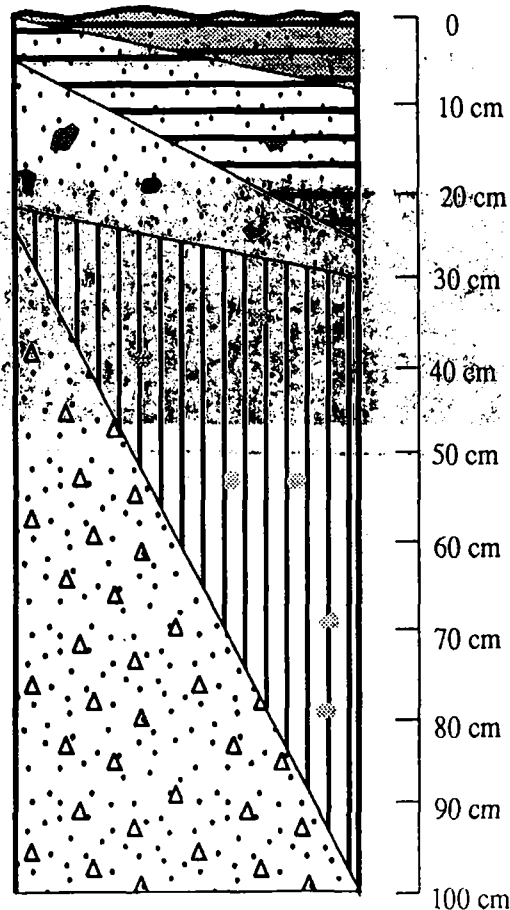
The soils on this LMU are generally dark greyish brown, sandy loam, overlaying a medium clay of depths sometimes exceeding 90 cm. The weathered bedrock is a low density granite, chalky and sometimes within 30-40 cm of the surface. The description below is typical of soils on this unit in the Byenup Catchment.

LANDSCAPE AND VEGETATION

These LMUs commonly occur on all slopes and low lying areas, often the deeper sandy profiles occur in the tops of drainage lines. Associated with Marri woodland (*Eucalyptus calophylla*) and also Sheoak, Wandoo, Jam, Redheart and Flooded gums in the lower slopes. Single and groups of Marri trees often characterise this land unit in the open paddock situation.

SOIL DESCRIPTION

- A1 Dark greyish brown (10YR 4/2)
Abrupt boundary
Weak, platy structure
Coarse sandy loam (course/medium)
Non-wetting
Medium acid (pH 6)
High organic matter
Fine gravel and quartz (2%)
Abundant roots.
- A2.1. Yellowish brown (10yr 5/4)
Weak blocky structure
Coarse sandy loam
Slightly acid (pH 6.5)
Low organic matter
Quartz/gravel fragments (5%)
Few roots
- A2.2 Very pale brown(10YR 5/4)
Coarse sand (bleached)
Slightly acid (pH 6.5)
Gravel stone 0.5-1cm diameter
Wavy boundary
- B1 Yellow brown (10YR 6/4)
Medium clay (coarse sand)
Yellow/orange mottles
Moderate, polyhedral structure
Neutral (pH 7)
Roots running on surface boundary



VARIABILITY

The soil variability on this LMU includes, the depth to clay, deep sandy duplex profiles and minor quartz rich duplex soils. Depths of 70-80cm are likely. This is the most dominant LMU of the catchment. It may require dividing into paddocks by using criteria of "slopes", "natural ability to drain", "amount of rock", "remnant bush", "potential to improve with drainage" as well as management requirements controlling paddock size. It is susceptible to 'blow' and recharge the groundwater, especially when identified with hillside seepage's. It is often at risk from water erosion on steep slopes and in a cultivated state.

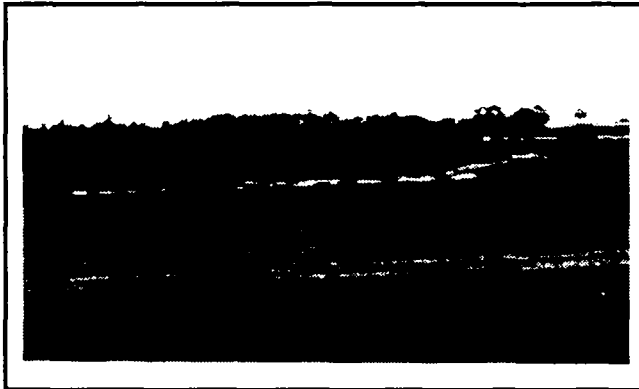
MANAGEMENT RECOMMENDATIONS

This land management unit covers the largest area of the catchment. Good management of this LMU in particular will have the largest impact on reducing degradation down slope and downstream.

Hillside seeps often develop down slope of a marri duplex or within the unit itself. Hillside seeps are caused by excess soil moisture flowing downslope through the topsoil until it is held up. (Where possible the cause should be treated rather than just focussing on the symptom.) To treat the cause all the excess soil moisture that would otherwise flow downslope should be used up where it falls. Perennial pastures and trees, have a large role to play in these situations. They will use up summer moisture that would otherwise be reducing water holding capacity of the soil in winter under annual crops and pastures. They have deeper roots which enable them to make better use of water passing through the soil. A belt of trees below a grade bank or perennial pasture between banks treated as a separate management unit, positioned strategically on the hillslope, will use the more sub-surface flow of water and prevent crops and waterlogging occurring further downslope.

Marri trees are the most vigorous growing on this unit compared to other local species. Crops and pastures grow up to the base of them. Therefore they are a good species to use in the paddock. See section on perennials for pasture recommendations.

A block of trees for water use.



DOLERITE SOILS LAND MANAGEMENT UNIT

IDENTIFICATION

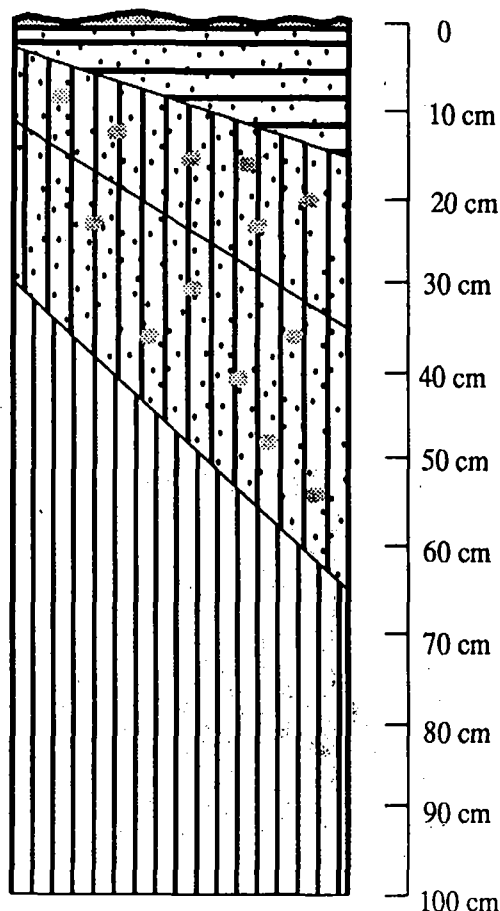
Dark brown or reddish brown sandy loams overlying a dark yellowish brown medium clay often 20 cm from the surface. Often described in the paddock as "heavy, fertile country." The soil description below is typical of these units in the Byenup Catchment.

LANDSCAPE AND VEGETATION

Often associated with ridges and slopes. These soils have formed from the grey, fine grained dolerite intrusive rock, occurring in NW-SE trends across the catchment. They are a major cause of hillside seepage due to the fine clayey soil textures being impermeable to groundwater movement and assist in dividing the catchment up into groundwater compartments (see earlier "Causes of seepages"). *Eucalyptus wandoo* is the dominant vegetation.

SOIL DESCRIPTION

- A1 Dark brown (7.5 YR 3/4)
Weak, subangular blocky structure
Sandy loam (med/fine)
Non-wetting
Medium acid (pH 6)
Very high organic matter
- A2 Reddish brown (5YR 4/4)
Polyhedral, blocky structure
Sandy loam
Neutral (pH 7)
Fine quartz (2%)
Some roots
- B1 Dark yellowish brown (10 YR 4/4)
Moderate - strong polyhedral blocky peds
Medium clay (fine/medium sand fraction)
Yellow mottles (5%)
Red/brown mottles (25%)
Neutral (pH 7)
- B2 Yellowish red (5YR 5/8)
Loose structure, weak and crumbly
Light medium clay (fine sand)
Shiny green/black minerals or weathered dyke material
Yellow mottles
- Parent Material:
Strong brown (7.5 YR 4/6)
Weak, light clay
5% fine weathered rock, symptoms of defoliated rock weathering.



VARIABILITY

The top 40 cm of these soils may be hardsetting if they have been repeatedly cultivated. Top soil may also be friable and produce surface cracks. Topsoil and subsoil pH can vary from 6 to 9. Stones in the profile can be ironstone gravel, quartz, granite, **dolerite** or gabbro.

MANAGEMENT RECOMMENDATIONS

Dolerite duplex has higher clay content therefore water movement through it is slower. This soil unit is the weathered material from Dolerite. Dolerite is fast cooled lava which has welled up in cracks in the earth's crust during movement of the earth plates. The cracks occurred in straight lines therefore soil unit generally occurs as linear features on the landscape. When oriented across slopes in catchments this soil may cause sub-surface water, coming from upslope, to seep out on the surface. If this is the case the sub-surface water should be intercepted and removed before reaching the seepage area by using banks or permanent vegetation. Run-off occurs because of an infiltration excess. Attention to working on the contour and incorporation of stubble will improve water infiltration and reduce water erosion caused by run-off.

Slopes where water erosion is occurring under present management should be protected with grade banks and waterway.

The nature of the soils on this land management unit is that during summer it sets hard on the surface. If not cultivated most pasture seeds cannot penetrate the surface and will not establish. Barley grass is an exception to this. Time of cultivation of the Dolerite soil is critical. Avoid working too dry or too wet.

If the soil has just the right amount of moisture a good tilth will be achieved and structure be maintained provided it is not worked too quickly. Time of cultivation is critical to achieve good establishment of pastures or crops.

Soils that have declined in soil structure can be improved by permanent pasture or increasing the number of years pasture in a rotation, or by direct drilling and stubble mulching.



Salinity encroachment onto shearing shed, yards, paddock and bush on the upper slopes at Crathie due to a dolerite dyke.

GRANITE SANDS LAND MANAGEMENT UNIT

IDENTIFICATION

The soils on this LMU often consist of an organic, topsoil with a slightly hardsetting crust. Generally forming a uniform profile with a dominance of coarse (quartz) weathered granite rock, size and distribution increases with depth. Granite outcrops nearby. The soil description below is typical of soils occurring with this unit in the Byenup Catchment.

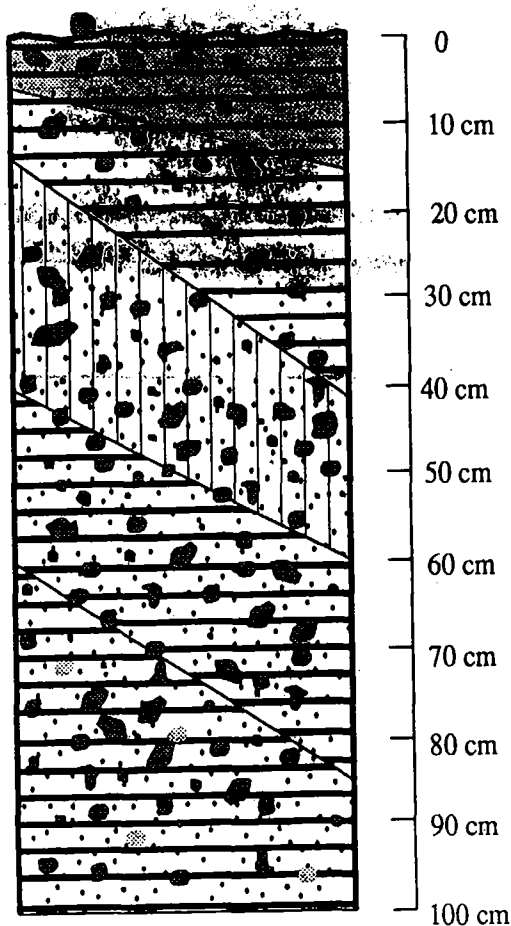
LANDSCAPE AND VEGETATION

These LMUs occur from the lower to upper slopes, often controlling the path of drainage lines (see aerial photographs). They are often a major contributor to hillside seepages (see 'Cause of Seepages', where vegetation still exists consider fencing to allow revegetation, this is very important on the deeply weathered, sandy profiles. The vegetation is dominated by rock sheoak (*Allocasurina huegeliana*) and Jam (*Acacia acuminata*) with occasional mixes of Redheart, *Eucalyptus decipens*, *Eucalyptus wandoo* and Marri *Eucalyptus calophylla*

SOIL DESCRIPTION.

- A1 Brown (10yr 4/3)
 Organic
 Sandy loam (medium/fine)
 Blocky structure
 non wetting
 Slightly acidic (pH 6)
 Rock fragments 15%
- A2 Brownish yellow (10YR 6/6)
 Fine sandy loam (fine/medium)
 Massive
 Mildly alkaline (pH 7.5)
 60% rock fragments
- B Brownish yellow (10YR 6/6)
 Coarse sandy loam
 Weak polyhedral peds
 Neutral (pH 7)
 75% weathered rock
- B Very pale brown (10YR 8/4)
 Orange/yellow mottles 30%
 Sandy loam (fine/medium/course)
 Mildly alkaline
 Decomposed granite parent rock

Northcote classification: Ucl.22



VARIABILITY

Often appear within areas of other land units, interfering with drainage lines and workability of paddocks. Easily confused with dykes. Can be a landscape problem when associates with 'bedrock-highs' and are also a recharge hazard in their deeply weathered form (as above) and where they occur as minor coarse deep sands. Also occurring in a duplex form, but characterised by the proximity of granite rock.

MANAGEMENT RECOMMENDATIONS

The granite sands support a natural vegetation cover of Sheoak (*Allocasuarina huegliana*), poison bush and other low water using plants. The vegetation indicates this soil is very dry for long periods of the year. The soil description shows this soil is of uniform texture with only a small percentage of clay in the A horizon hence allowing water to pass through very quickly.

Granite rock often outcrops or is very close to the surface in this unit. Water running off the granite and soaking in will be recharging the groundwater aquifer if it is not transpired by deep rooted perennial vegetation.

A belt of trees around granite outcrops and the shallow granite sands is recommended. Local native species that can be used are:

Allocasuarina huegliana (Heugels casuarina), *Acacia acuminata* (Jam tree), *Eucalyptus decipens* (Redheart or Moitch). See the section on perennials for possible alternatives.

***Eucalyptus decipens* growing naturally on the sands.**



GRAVELLY SANDY DUPLEX LAND MANAGEMENT UNIT (LMU)

IDENTIFICATION

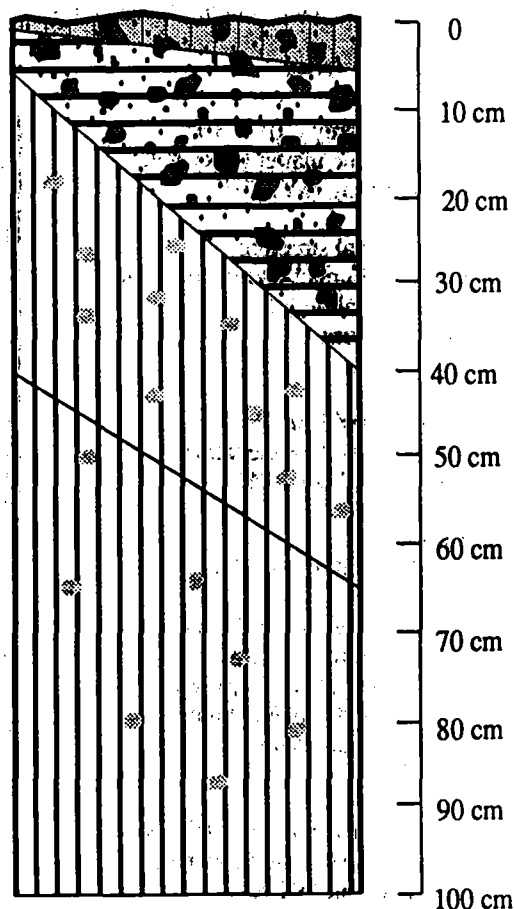
The soils on this LMU consist of a loose gravelly topsoil high in organic matter with an A2 layer dominant in gravels. The B layer has a high percentage of strong red/orange coloured mottles. The pallid or white clay component increases with depth, this layer is recognisable from a 'smooth talc' - feeling when dry. The description below is typical of soils on this unit in the Byenup Catchment.

LANDSCAPE AND VEGETATION

The LMU has a landform pattern tending to the upper slopes and ridges. It has a high recharge hazard and any native bush such as jarrah with scattered Wandoo and Marri should be protected. The gravelly profiles may have supported dense stands of Jarrah woodland. Otherwise consider combining a high water using project such as Tagasaste with the trees.

SOIL DESCRIPTION

- A1** Very dark grey brown (10yr 3/2)
Clayey sand (medium)
Non wetting
Neutral (pH 7)
High organic matter
40% medium/coarse irregular gravel stones.
- A2** Yellow brown (10YR 5/6)
Fine sandy loam (fine/medium)
Mildly alkaline (pH 7.5)
60% fine/medium rounded gravel
Loose structure, tree roots
- B1*** Yellow (10YR 7/6)
45% red mottles
Medium clay (medium sand)
Slightly acid (pH 6.5)
Good rooting depth
Weak platy structure
- *** Yellow (10YR 7/6)
20% red/yellow mottles
Light clay (medium sand fraction)
Medium acid (pH 6)
- *** Weathers off rock
Northcote classification: Dr5.31



VARIABILITY

The gravel proportions may vary. Layering of sands and then gravels often occurs. Often downslope is where more mixing and sorting has occurred, and often the sand is more dominant on the surface.

MANAGEMENT RECOMMENDATIONS

The soil of this unit, although a duplex, has high internal drainage as evidenced by the red mottles that are formed by water movement through the profile. The clay is medium with a flat structure and there is also good root penetration through it. This soil unit is a significant recharge area for the groundwater aquifer. Reducing recharge to the groundwater aquifer is a very important part of controlling valley floor salinity and is best done using trees.

Jarrah, Marri and Wandoo are the main species growing on this soil unit and are all good water users. When planting trees on this site the Wandoo prefer the areas of shallow topsoil and the Jarrah and Marri prefer areas of deeper topsoil.

In terms of nature conservation these woodlands provide a very important habitat for bird life because a high percentage of birds in the south-west region require nest hollows to breed. This soil type mainly occurs on ridges in the catchment and if wooded provides the additional wildlife corridors and protection of hilltops from wind erosion.

FLOODED GUM AND SALINE VALLEYS LAND MANAGEMENT UNIT (LMU)

IDENTIFICATION

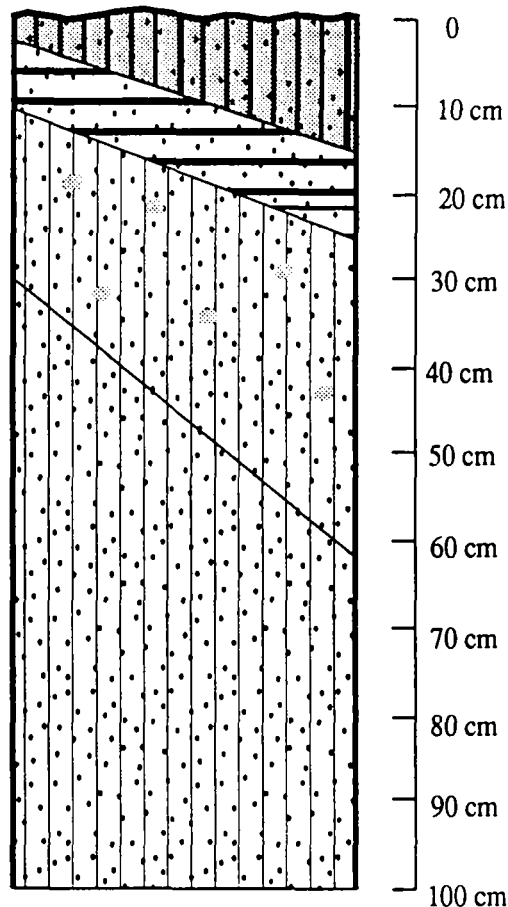
The soils of this land management unit comprise of highly organic topsoil, with surface crust when dry. Often described as a gradational soil profile with gradual 'decrease' in clayiness with depth. The organic clayey topsoil may be lost by clearing of flooded gums for cultivation. This layer has often led to this soil being described as a light grey clay.

LANDSCAPE AND VEGETATION

This LMU makes up the catchment drainage lines and tributaries. They are often intersected by other units, such as the Dolerite soils. Here many of the saline seeps have appeared. Particularly where more than one tributary join. The gullies are narrow and well incised in the catchment, however further downstream they broaden more. The gullies are well vegetated with Flooded Gums and a variety of T-tree species.

SOIL DESCRIPTION

- A1 Very dark grey (10YR 3/1)
High organic matter (silky feel)
Red mottling (5YR 3/1)
Moist
Strong pedal structure
Light medium clay (medium sand)
Mildly alkaline (pH 7.5)
Stones absent
Many roots
- B1 Brown (10YR 5/3)
Sandy loam (fine/medium)
Fine gravel/rock (1%)
Good roots
Moist
Mildly alkaline (pH 7.5)
- B2 Light yellow brown (10YR 6/4)
Orange mottles (30%)
Moderately alkaline (pH 8.0)
Clayey sand (fine/medium)
Good rooting depth
Moist
- Light yellow brown (10YR 6/4)
Clayey coarse sand (fine, med. coarse)
Slightly acid (pH 6.5)
Weathered granite at 100-130 cm
Very wet.



Northcote classification: Gn 2.81

VARIABILITY

This soil description is influenced by the proximity of the granite and depth of river sediments to bedrock or clay. Generally a duplex soil occurs in the flooded gum gullies, however the clay layer is frequently below 70 cm. Top soils are high in organic matter forming sandy clay loams, to clay sands over a light medium clay at 20-60 cm depth. Prone to salinity, often due to impeded water flow caused by another unit. Dead trees and barley grass often present in salty gullies.

MANAGEMENT RECOMMENDATIONS

These soils are essentially a granite sand except the bedrock is closer to the surface and the top 10 cm is a silty clay loam. They have a high internal drainage but are often wet due to sub-surface flow from all sides.

In the catchment some of the flooded gum valleys have turned salty, particularly at confluence points in the streams. Inflow of water in these areas has been so great that they have become waterlogged and subsequently turned saline.

The same approach to treatment of these soil types should be taken. Allow safe waterway widths uncultivated such that peak flows are contained on undisturbed ground. Allow the waterways to regenerate naturally or revegetate them and exclude them from stock.

To reinforce earlier comments on water use at Stene's farm in the Wellington Catchment Valley Reforestation has lowered the saline groundwater tables in the vicinity of the stream by 1.5 m (N. Schofield, 1990). The reforestation covered an area 100 m either side of the stream and was at a density of 625 trees/ha.

Vegetation in the valleys will use up sub-surface water flowing in from the slopes. This is however the last line of defence against the valleys becoming waterlogged. To reduce the pressure on the valleys a major effort to use up water where it falls further up slope should be made.

Possible strategies include the use of:

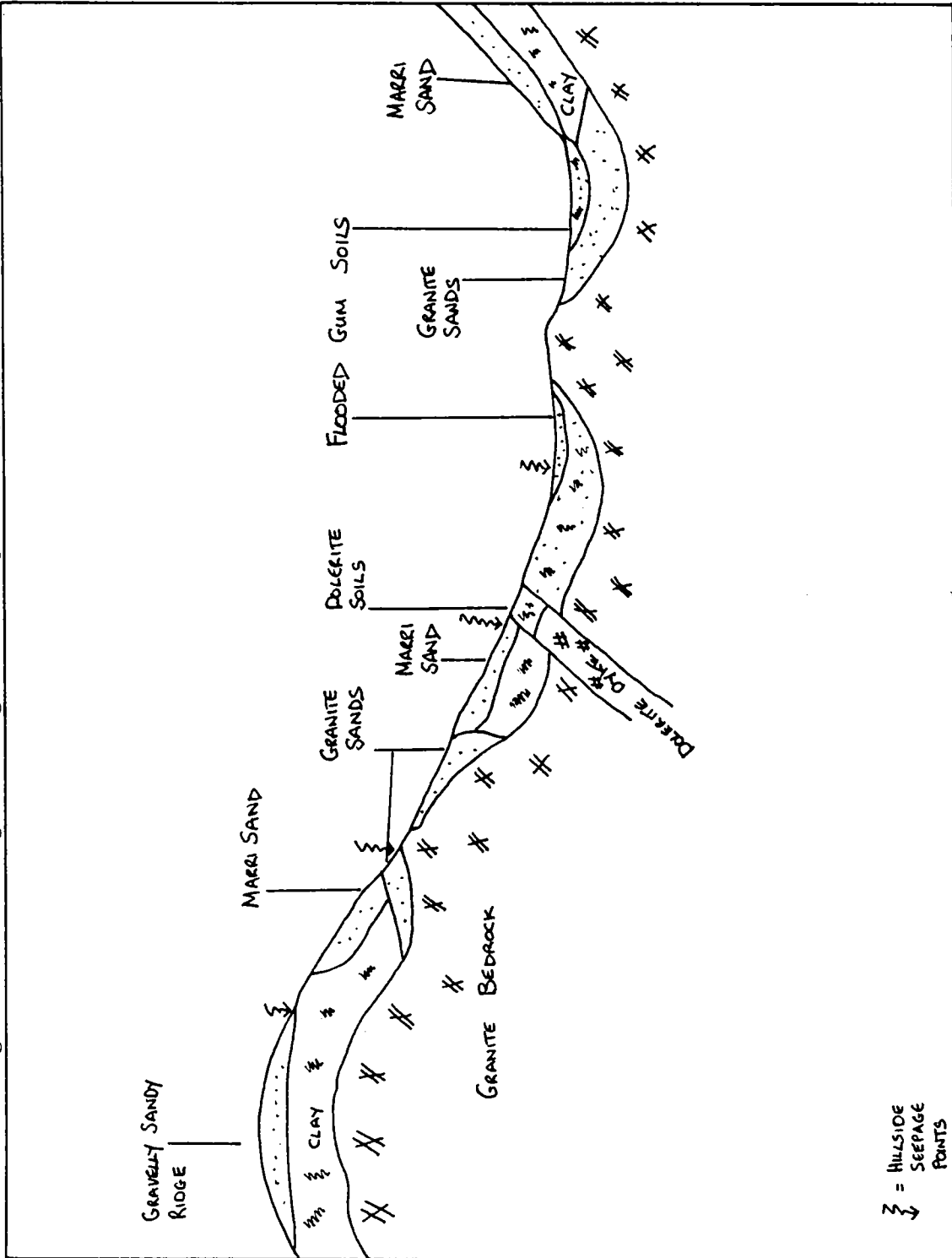
- i) perennial grasses - higher water use, longer growing season, over large areas of the catchment.
- ii) Contour banks and waterways - controlling run-off, preventing ponding.

Revegetation of saline parts of the valley may be done by planting salt-tolerant, waterlogging tolerant trees in barley grass and fresher areas around the outside of the scald. As the scalded area is in a drainage line it will be very prone to water erosion. Salt tolerant grasses either puccinellia or salt water couch would be best suited for this purpose. See saltland agronomy in the Appendices for further information.

Natural regeneration of the flooded gum valley once fenced off



Diagram 2: Schematic diagram showing the relationship of soils in Byenup Catchment.



3. Recognition, planning and treatment of land degradation

Wind erosion

Recognition

A wind eroded paddock does not look that alarming to the eye unless there has been a major wind event. This is because the effect of wind erosion is very dispersed, only thin sheets of soil are displaced and differences of before and after a wind event are not very apparent.

Impact/consequences

A wind eroded paddock generally has a smoother look on the surface compared with the rough surface of a cultivated paddock. What is more apparent is yield losses at harvest. In the early stages of growth crops are most susceptible to sand blasting because of the loose cultivated soil and lack of ground cover. Shifting sands will damage narrow leaved plants setting them back a few weeks and can kill young broad leaved plants by damaging the growing tip.

There are two times in the year when soils are most prone to wind erosion. These are in summer due to grazing pressures and, in winter due to cultivation. Careful management of paddocks will reduce their susceptibility to wind erosion at these times of the year. Alternatively windbreaks can be used to change the micro climate of a paddock which makes it less susceptible to wind damage and can increase production.

Summer grazing

One sheep can detach $\frac{1}{3}$ tonne of soil per week on hard setting soil and 1 tonne of soil per week on sandplain. This material can be blown away if not protected by ground cover.

Many weeds and all legumes are easily broken by stock trampling and are blown away in moderate winds. Grasses can withstand trampling better and therefore are better able to protect the soil. Ideally, an evenly mixed sward of grasses and clovers will protect soil from erosion.

In pastures, it is recommended that there should be at least $\frac{1}{2}$ tonne/ha of anchored grasses to prevent wind erosion. In doing a feed budget of pastures the aim would be to have at least $\frac{1}{2}$ tonne/ha of anchored grasses in the paddock at the end of the summer period.

In the cropping paddocks it is recommended that 1,000 kg DM/ha of cereal stubble or 2,000 kg DM/ha of lupin stubble anchored is the minimum effective cover for preventing wind erosion. To determine the above mentioned acceptable plant covers refer to Farmnote No. 40/90, "The amount of stubble needed to reduce wind erosion".

Winter cropping

Susceptibility to wind erosion in the winter cropping phase is determined by damage to soil structure timing of cultivation and amount of plant residue retained.

Moisture, speed and type of cultivation

Speed of cultivation should be reduced if moisture declines and cultivation should stop altogether if clouds of dust begin to rise. At this stage clods of soil are being shattered, therefore smashing the soil structure.

Direct-drilling, soil rolling or packing are desirable practices as they reduce risk and delay erosion process but they do not prevent erosion and strong winds can still cause considerable damage.

Do not rely wholly on direct drilling.

Plant residue is the key to crop protection

Current research indicates that stubble retention is an effective way of preventing wind erosion on cultivated soils. Stubble height is not as critical as straw spacings. Farmnote 40/90 shows very simply what a suitable cover of crops looks like. It is recommended that 1,000 kg DM/ha of anchored cereal stubble or 2,000 kg DM/ha of anchored lupin stubbles is an effective cover required to prevent wind erosion.

Windbreaks

Treatment

The main purpose of a windbreak is to reduce the force of strong winds which has the effect of:

- controlling soil erosion;
- reducing evaporation and evapotranspiration by plants;
- reducing mechanical damage of sheltered plants;
- protecting young lambs and off-shears sheep from windchill;
- increasing opportunity to spray or carry out other management practises.

Windbreaks have other beneficial uses such as increased water use and tree and shrub products which can be utilised.

Potential gains from windbreaks, or losses from exposure, have not been documented in Australia. With the information available it is safe to say that many areas would get net increases in pasture growth, crop yields, sheep survival and productivity from the presence of planned windbreaks (D. Bicknell, 1990).

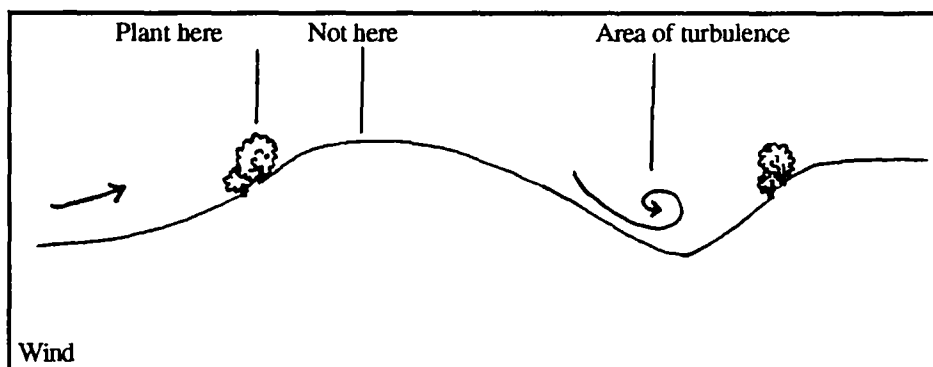
Principles of design

For maximum windbreaking effect shelterbelts should filter rather than block wind. The recommended permeability is between 40-60 per cent. Shelterbelts that are too dense create wind eddys which can lead to erosion.

A good height is required. The taller the tree the further the controlling effect. Wind speeds are reduced by 50 per cent up to ten times the height of the tree away from the windbreak.

On sloping paddocks the effective distance is reduced with increasing slope. The most effective placement of windbreaks in hilly areas is just below the crest on the windward side, parallel or perpendicular to the contours. Placing the windbreak on the crest makes the hill sharper which increases eddying to leeward (Findlater, 1991), see below:

Diagram 3: Avoid planting windbreaks on the hilltops



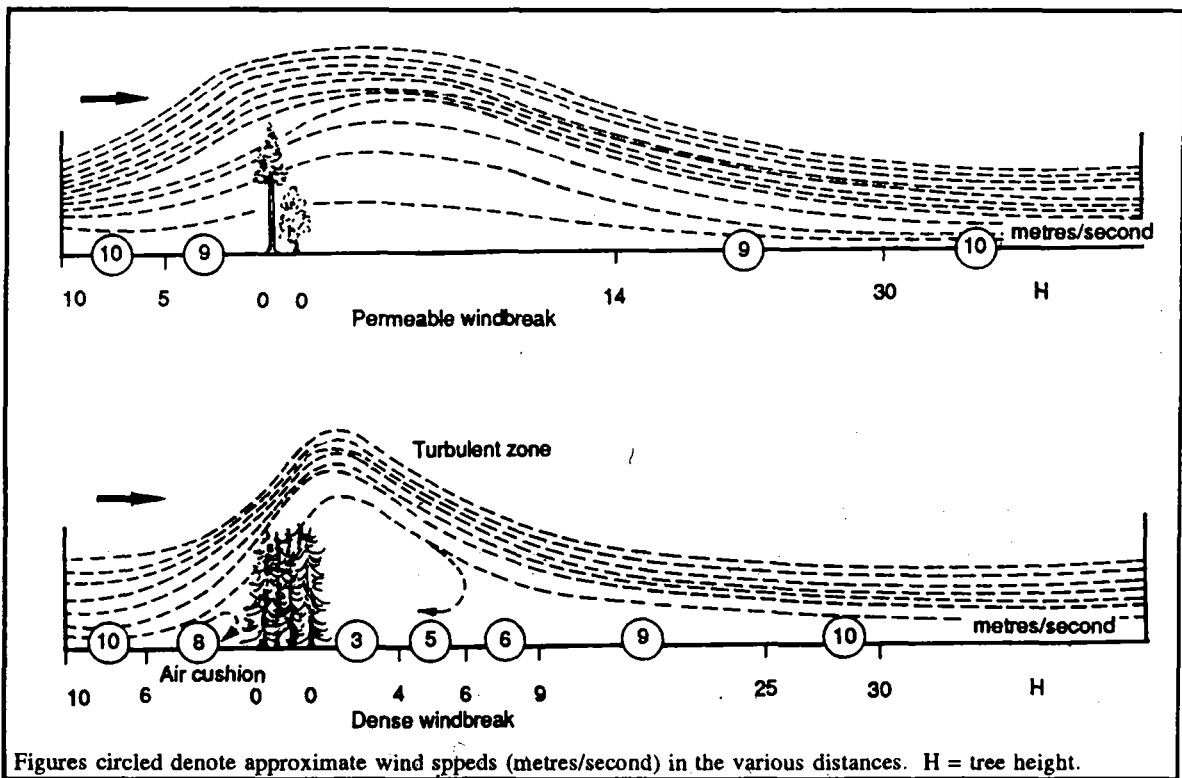


Diagram 4: Effect of windbreaks on the flow of wind,

Tree species that retain their bottom branches are required or they must be complemented with lower shrubs. Having no vegetation low in the shelterbelt causes wind tunnelling.

Two or three rows of vegetation generally gives the right permeability. The rows are usually five or six metres apart and trees within the rows are three metres apart.

The maximum windbreaking effect would be gained by having the shelterbelts ten to twelve tree heights apart. This may however be impractical and a compromise will have to be worked out. Opportunities for windbreaks such as banks, ridges and valleys will also influence the positioning of them within the farm plan because these areas are often fenced on one or both sides, so reducing the expense of additional fencing. Shelterbelts must be excluded from stock during establishment and grazing of foliage should be prevented once they are established to prevent tunnelling.

Plant growth between windbreaks 12.5 tree heights apart can increase 20% and 25 tree heights apart can increase 10% (D. Bicknell, 1990), see below.

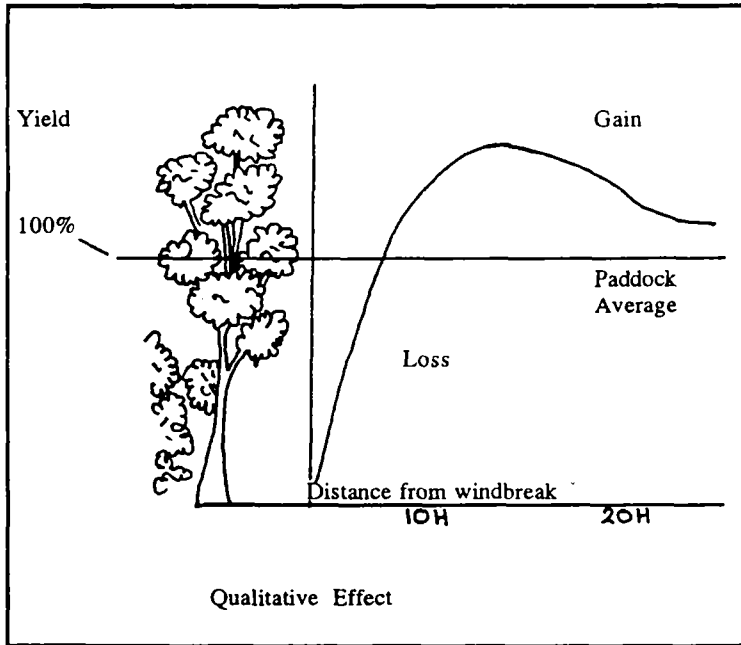


Diagram 5: Tree windbreak affect on pasture and crop yield

In Summary: wind erosion/corridors/ground water recharge

1. What is wrong with present management? When all else fails what will prevent erosion from happening?
2. What is the soil unit? Which species grow best? Determine soil type and tree species best suited.

e.g. Marri slopes	Marri
Gravel ridges	- Jarrah, Marri, Wandoo
Granite sands	- <i>Allocasuarina</i> sp., <i>Eucalyptus heugliana</i> , <i>E. decipens</i> .
3. Design strategic plantings to overcome the problem. Windbreaks, corridors, groundwater pumps.

Waterlogging

Recognition

Lack of oxygen is the major cause of limited plant growth in waterlogged soils. Gas spaces in most well drained soils make up 10 to 60 per cent of the soil volume, and various gasses diffuse rapidly into and out of the soil. When the soil is waterlogged most of the space becomes filled with water, soon all the available oxygen is consumed. (Setter et al., 1990).

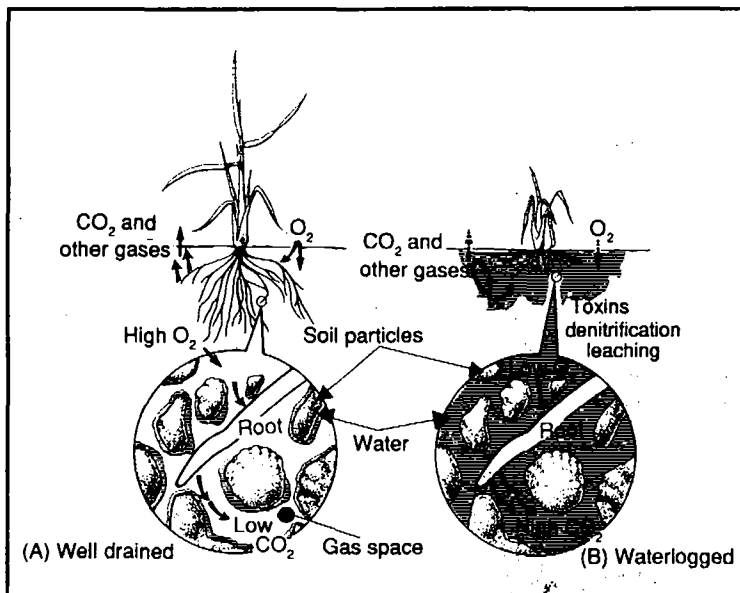


Diagram 6: Reduced diffusion of gasses owing to waterlogging.

Visible effects on plants include reduced size and yellowing of leaf tips, and yield losses are experienced if the root zone of crops and pastures is saturated. Financial losses caused by waterlogging were estimated to be \$1.1million in 1988.

The solution to waterlogging depends upon landscape position and the soil in question. On slopes, *seepage interceptor drains* have been found to be very effective in reducing waterlogging and are reasonably cost effective.

Constructing seepage interceptor drains will be worthwhile for draining duplex soils, with up to 50 cm of topsoil, on hillslopes when waterlogging during a cropping year can be expected at least one year in ten. Waterlogging control is essential above mildly salt affected areas to prevent the combined effects of salinity and waterlogging reducing crop yields (McFarlane, 1985).

On shallow duplex soils, i.e. topsoil less than 25 cm depth, grade banks will intercept sub-surface flow because the channel depth is 30 cm. There is also greater likelihood of water run-off because of the lower water holding capacity of the topsoil. The grade bank is better suited to controlling surface water run-off because of the wide flat bottom channel and is therefore a better choice on shallow duplex soils that are prone to waterlogging.

Additional benefits in using seepage interceptors and grade banks are, they enable contour working, thus reducing water erosion and they decrease groundwater recharge by draining perched waters. In order to reduce recharge they must be on a grade so that water is not stored in them.

Use of relief drainage

On flats the control of waterlogging is more difficult because there is often insufficient grade for drains to be effective.

The approach that is most often taken by farmers is to remove as much surface water as possible by connecting up the low lying areas with spoon and W-drains. Collectively known as relief drainage, spoon and W-drains follow the depressions in a paddock and may range in grade from zero to 0.5 per cent grade. They have a shallow channel, (see Drain design sheet in appendix), and are open on both sides thereby allowing water to drain in from both directions. At certain places in the paddock the channel may need to be cut deeper, through a high point, to maintain a zero or positive grade so that ponding in the channel is prevented.

In areas with poorly structured soils, adding gypsum (followed by minimum tillage) may be one way of reducing waterlogging. On gypsum responsive soils, gypsum will improve the soil structure, and water infiltration rates of the soil thereby reducing the time of waterlogging.

In summary to prevent waterlogging over large areas of duplex soils:

1. Check average soil depths to clay
 <30cm grade bank
 30-50 reverse bank interceptors
2. Explore other options with tree belts or perennial vegetation.

Water erosion

Recognition

Water erosion takes three forms. Sheet, Rill and Gully erosion as already discussed. Water erosion in all its forms generally does not occur if there is a permanent, dense vegetation cover. Most farming systems however, cause the ground to be bare or unprotected at some time of the year.

Working on the contour

Cropping paddocks with long slopes steeper than 0.5% will benefit from cultivating on the contour or on a grade by reducing water erosion. On lower slopes that are waterlogged cultivation should always be on a grade between 0.2% and 0.5% to prevent water ponding on the surface but also prevent water erosion. On slopes greater than 2% the soils in cropping paddocks should be protected by grade banks running to a waterway and contour cultivation between them.



Protection of hill slope with grade banks

Calculations of water-way widths will not be covered here as there are many considerations and pitfalls in waterway design. Your local Department of Agriculture Land Conservation Officer should be sought for advice on the design of waterways and other specific engineered earthworks such as roaded catchments. Although roaded catchments should be considered as a last resort for filling dams with water.

The following design steps are provided so that certain layouts in the paddock can be thought about or even tried so that by the time it comes to seeking advice on the detailed parts of the design many of the possibilities for improvement of paddock layout will have been considered. For instance, protecting a soil type which has a particular erosion hazard may open up the possibilities of reclaiming erosion gullies or fencing to soil type or creating a safer all weather track all of which would all be an improvement either to the management or productivity of the farm.

In summary steps to control water runoff and erosion

1. Select waterway.
2. Determine safe length of non-errodable slope.
3. Survey in level lines for working on the contour and leave waterways, or have a grade bank and waterway system designed by a Land Conservation Officer or Community Landcare Technician..
4. Use lines surveyed in to work to and install banks when time and money permit.

1. Waterway selection

Selection of a waterway is an important part of the whole design as everything else hinges upon it. Select a large stable (e.g. not eroding) natural depression or creekline as your main waterway. Generally only in special instances would an alternative site be chosen, e.g. large even sloped areas with no natural depression or the existing depression is very badly eroded and should be avoided at all costs.

A mildly eroded gully can be reclaimed and this must be done before constructing grade banks if going to use the depression for a waterway.

In protecting paddocks water is sometimes taken from another catchment and put into the main catchment for convenience of working. This practice is only acceptable if the water being diverted from one catchment would naturally flow into the waterway or creek before leaving the landholder's property. Doing otherwise is creating an illegal diversion and is against the law.

Select a natural depression that extends a long way up the paddock or hill so that it is possible to dispose of water high up in the catchment. The area of catchment that is draining into a waterway will determine the width of waterway and its priority for fencing. Major waterways should be fenced and therefore will sometimes become the boundary for the new paddock layout (a good example exists on the Doodledup property).

2. *Bank and working line spacings*

Level line or grade bank spacing can be determined by using the "Calspace" formula. This formula is designed to provide safe following distances between banks and level lines such that erosion does not occur.

The two variables E and S in this formula must be obtained from the paddock being treated. Slope is measured in per cent which is found by dividing the vertical distance by the horizontal distance between two points up and down the slope and multiplying by 100 (see diagram).

Bank spacing ("Calspace")

$$\text{Bank spacing (m)} = \frac{E}{S} + R \times 100$$

E = Erosion hazard (see Table A).

S = Slope %.

R = Rainfall factor (see Table B).



Reverse interceptor drain under construction by grader at Cranham.

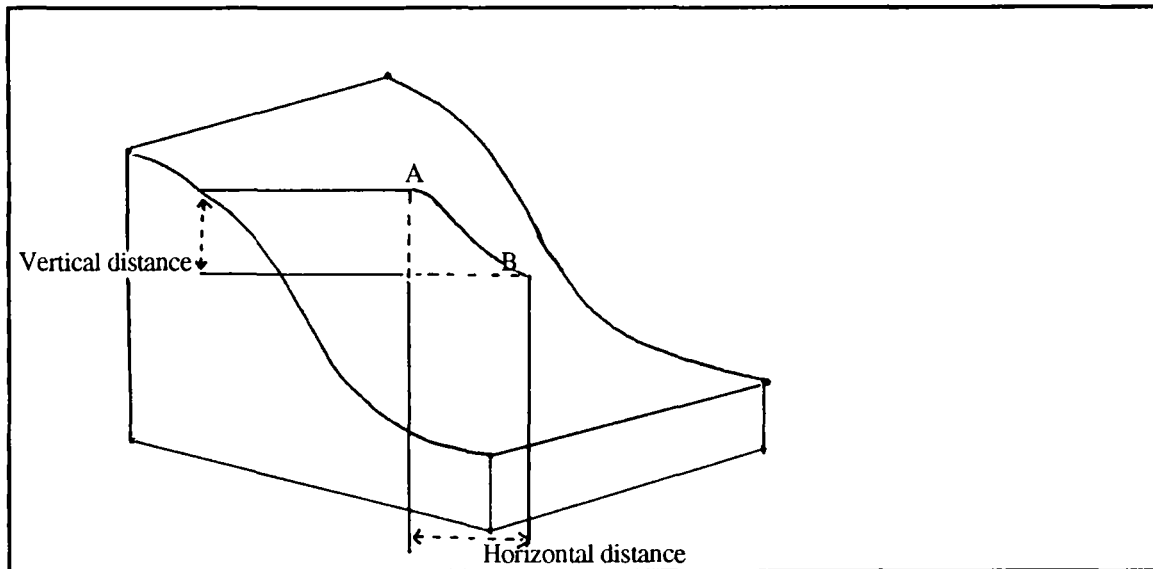


Table A. Value of E (Erosion Table B)

	Upper slope	Mild slope	Lower slope
Minor erosion	3.00	3.00	3.50
Sheet and rill erosion	2.50	2.75	3.00
Rill and gully erosion	2.00	2.25	2.50
Severe-gullies-soil problems	1.50	1.75	2.00
Soil problems-massive erosion	1.00	1.25	1.50

Table B. Value of R (Rainfall factor)

Annual rainfall (mm)	R
300- 35	1.00
400-450	0.90
500	0.85
550	0.80
600	0.70
650	0.70
700	0.65
750	0.65
800	0.60
850	0.55
900	0.50
950	0.40
1000	0.30

Paddock to be treated

e.g. $\frac{\text{Vertical}}{\text{Horizontal}} \times \frac{100}{1} = \frac{0.4 \text{ m}}{50 \text{ m}} \times 100 = 0.8\%$

To get the slope measurements either level and staff or a clinometer are required.

3. Position and survey of working lines and banks

Working lines and banks create opportunities for tracks, belts of trees and fences and their good positioning will enhance the overall workability of the farm. The positioning is also determined by the availability of safe disposal sites on the waterway. The ends of the proposed grade banks must have safe disposal points so that erosion does not occur. The first Working line or grade bank may be moved up and downslope until the best fit is found. Then the following lines are surveyed in at the regular intervals, determined in "Calspace". The line intervals may be reduced if one of the above criteria is not met, e.g. an unsatisfactory disposal point.

Working lines are surveyed in on the level but the grade of grade banks will vary between 0.3% and 0.5% according to the stability of the soils they are constructed on. It is recommended that the length of banks does not exceed 800 metres in either direction from the waterway otherwise the dimensions of the bank should be increased

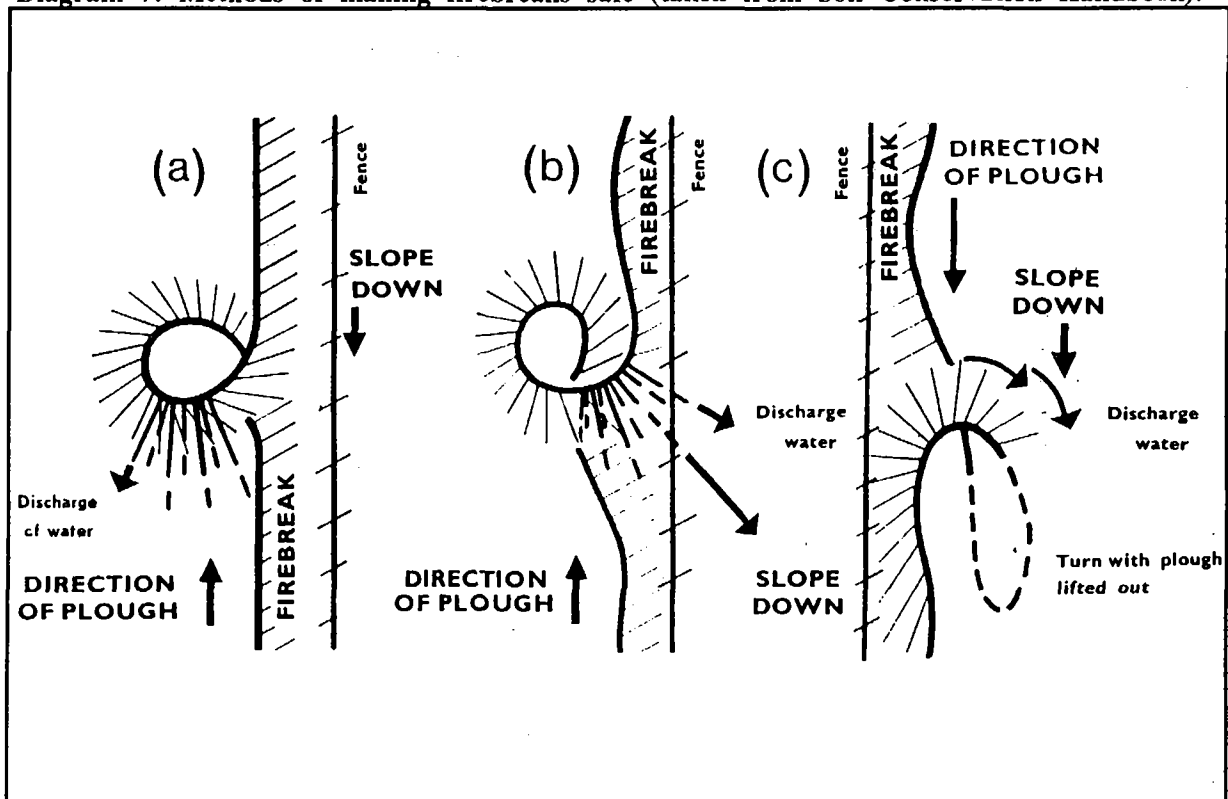
4. Begin using surveyed lines



The present firebreak here is the third in a succession of eroded firebreaks.

Most shires allow firebreaks to deviate from paddock boundaries to follow the lie of the land or contour banks. This should be taken full advantage of in efforts to reduce erosion on firebreaks. Some sections of firebreak however, are going to be oriented up and down slopes. To prevent these sections from eroding, make loops at frequent intervals down the slope that divert water onto grassed areas.

Diagram 7: Methods of making firebreaks safe (taken from Soil Conservation Handbook).



• Waterways

Waterways have an important role in the safe disposal of water. They carry concentrated flows of run-off from a rainfall event without erosion.

Waterways are more prone to water erosion because of the high volumes of water they carry at times. If not managed more carefully than the rest of the paddock waterways will erode, e.g. when cultivated across for crops or over grazed by stock they are very prone to eroding.

Natural waterways in which natural vegetation is left also become erosion prone if unfenced. The ground cover in natural bush is not as vigorous as pasture species. Once eaten out by stock regeneration is slow, the soil very quickly becomes powdery due to trampling by stock and hence very prone to erosion.

Waterways should be permanently protected with vegetation. Depressions in the paddock where water naturally runs should not be cultivated but left to stabilize with pasture species. Prevent working of these depressions by marking with steel posts for minor waterways or by fencing for major waterways.

Natural waterways where the original vegetation still exists should be excluded from stock. This will prevent removal of ground cover and soil disturbance by stock and allow the natural vegetation to regenerate.

Safe waterway widths should be calculated by your Local Land Conservation Officer before starting to fence them off. See the Waterways and Banks Design sheet, for information on their purpose and design.

- **Dam overflows**

Much money and effort goes into making a dam but most often they are not finished off properly. For a little bit extra effort the investment could be prevented from eroding away.

Dams, once full, overflow at the same rate as they are filling. In large rainfall events where the runoff far exceeds the dam capacity dam overflows will erode if they have not been constructed properly.

In most cases no attempt is made at constructing a dam overflow. It is quite common to see deep gullies alongside a dam eroding away the side wall or, even in advanced cases, lowering the capacity of the dam.

The dam overflow should be designed to carry as much water as the waterway above it. The correct width of the dam overflow will be similar to the waterway above the dam, but will vary according to the slope. Your Local Land Conservation Officer can determine the correct width.

If the calculated width is narrow it may be considered worthwhile constructing an overflow with flat cross-section alongside the dam back into the main waterway.

If the calculated width is wide it will be cheaper to build a bank from the dam outlet away from the dam and dispose of the water through a level sill onto a stable grassed area. The grassed area below the level sill should be fenced off.

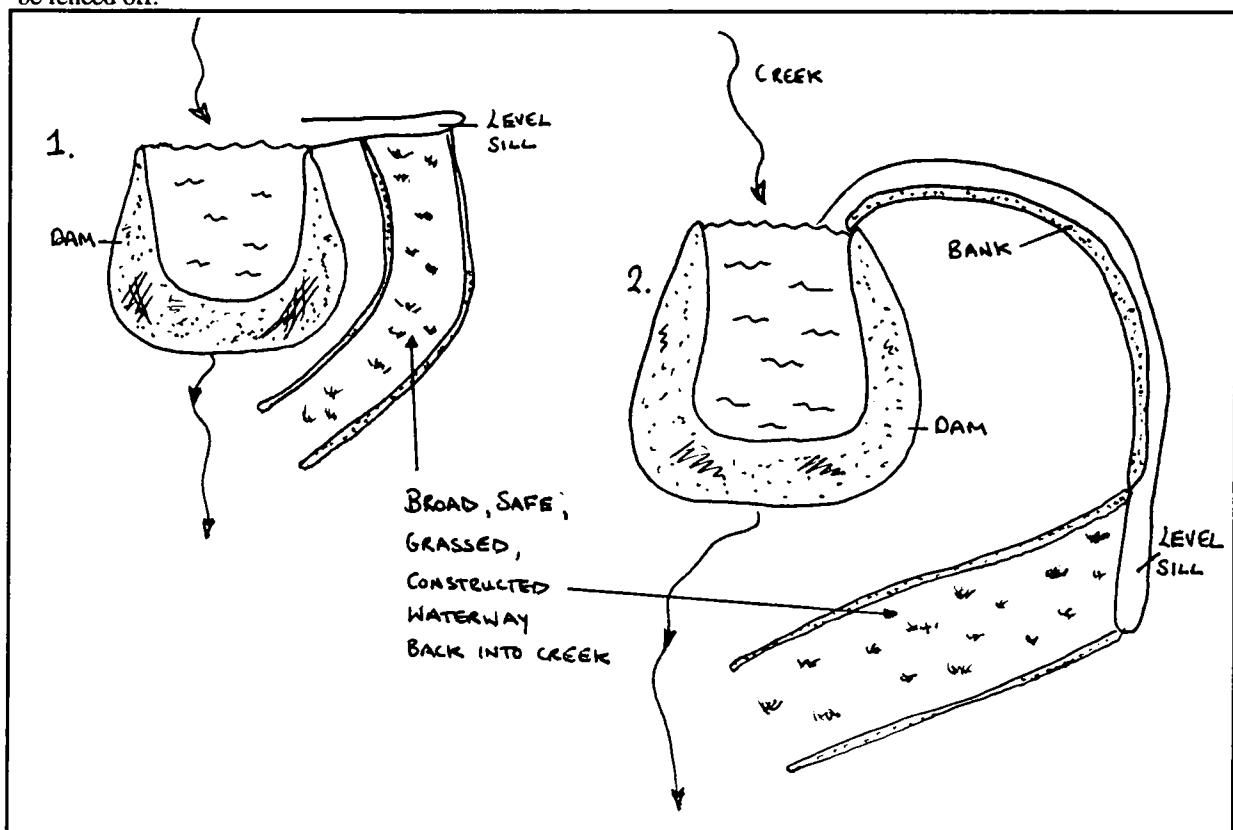


Diagram 8. Alternatives for level sills.

- *Gateways and stock watering points*

Gateways and stock watering points often become bare in summer due to concentrations of stock and traffic. Positioning gateways in natural depressions and troughs on sandy hillslope will lead to erosion. When planning the farm layout, this is the time to fit everything together such that gateways don't end up in drainage depressions. Watering points are put on harder, less erodible soil or are put in areas where they are less prone to erosion.

If there are no major plans to change the farm layout the problem areas should be dealt with as they arise.

- *Farm tracks and crossings*

Farm tracks are usually bare all year round therefore are susceptible to erosion at any time.

A similar approach to the placement of firebreaks should be taken when placing farm tracks, i.e. farm tracks should not follow paddock boundaries in areas where they will cause erosion. Tracks should be placed alongside grade banks or along ridges which have a reduced risk of water erosion and are generally safer places for the movement of heavy vehicles.

Major tracks, e.g. access laneways, should be formed up correctly with a crown in the middle of the road that is about 5-10% the height of the road width.

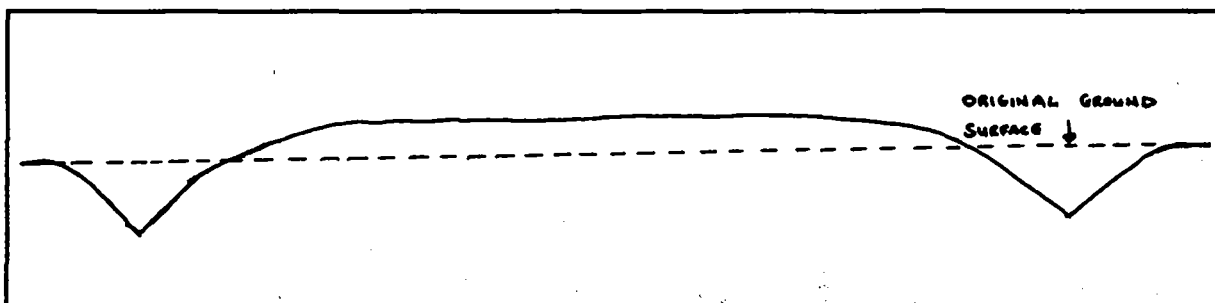


Diagram 9. A typical road cross section on flat ground or running directly downslope.

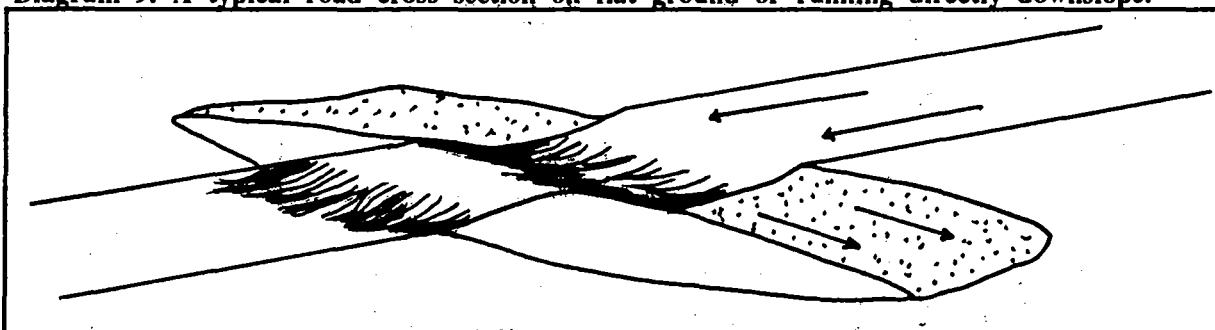
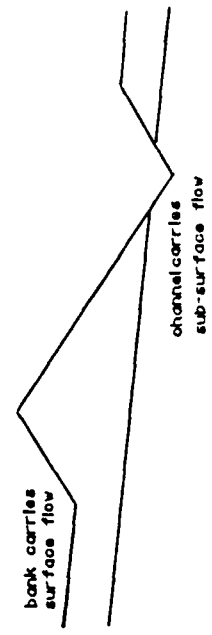


Diagram 10. Cross-section and perspective view of a shallow diversion ditch to divert flow off a farm track.

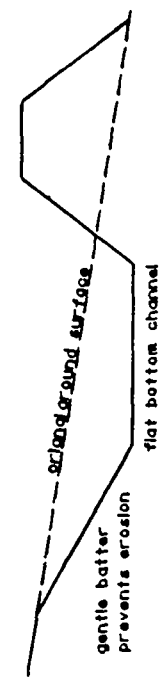
The spacing between shallow diversion ditches will be very variable depending on erodability of the soil. Determination of the distance between ditches should be done by close observation of soil movement by water on the track. Put the shallow ditches just upslope of areas on the track where there are obvious signs of soil movement.

Selection of soil conservation earthworks

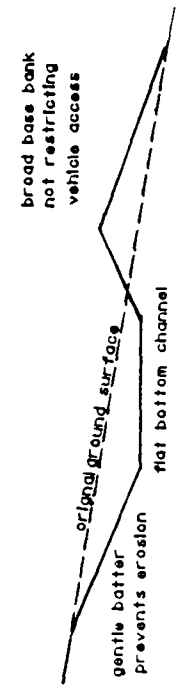
Structure	Construction machine	Position in landscape	Purpose	Slope	Grade along channel	Channel depth	Channel width	Bank dimensions
Grade bank	Grader, bulldozer or tractor and plough	Upper to mid-slope	To control surface runoff and erosion	2-15%	0.25%-0.5%	20-30 cm	3-4 m	Height 50-60 cm+
Level/absorption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



Reverse bank seepage interceptor


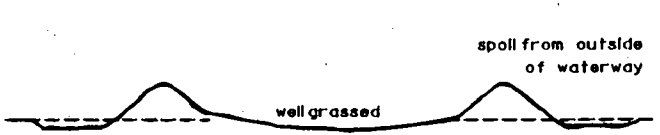
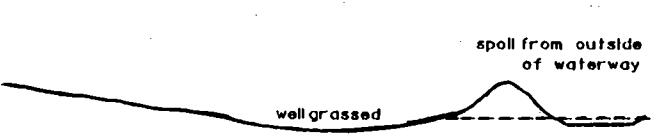


Absorption bank

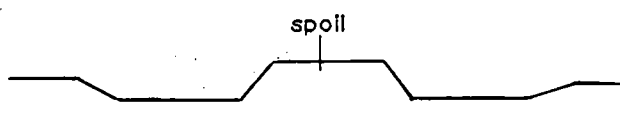
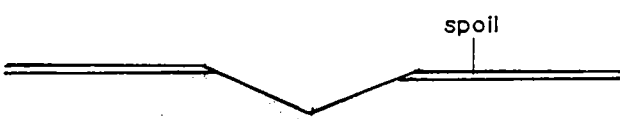
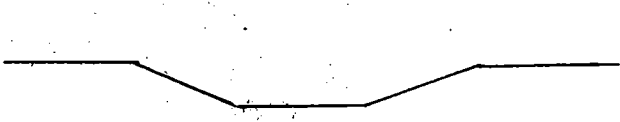


Grade or level bank

Leveed waterways designed to confine water flows

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

Relief drains designed to allow water in from both sides.

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

Further reading in relation to treating land degradation

- Western Australian Department of Agriculture Farmnote 40/90. The amount of stubble needed to reduce wind erosion.
- Farmnote 102/88. Fitting trees into the farm plan.
- Farmnote 32/86. Saltland Management-selecting farm plants for saltland. Growing trees on Australian farms.
- Dicknell. The effect of tree shelter on agricultural production. Agroforestry Seminar. CALM, Esperance.
- McFarlane. T. Negus, J. Cox. "Drainage to control waterlogging" pp 122-125. Journal of Agriculture, No. 4 1985.
- Nulsen. Hillside McFarlane. pp 128-129. Journal of Agriculture No. 4, 1985.
- Schofield. "Lowering saline groundwater tables by valley reforestation". Land and Water Research News. pp 22-25. Issue No. 7 August, 1990.
- Department of Soil Conservation Guidelines for Plantation. Tree Farming, 1990.
- Findlater. "Low cost strategies to control wind erosion". Green Brook catchment management report, 1991.
- McFarlane. "Hydrology of Waterlogging", July, 1987.
- Components of the water balance on duplex soils in Western Australia pp 845-855. P.J. Gregory, et al., 1992.



Water should not be stored in banks



Protection of remnant vegetation is the cheapest method of revegetation

OBJECTIVE 3

Protect and enrich the *native plant and animal habitats* occurring in the catchments.

Outcomes and Actions:

1. To protect all native vegetation over five hectares in the catchment, and consider carefully the value of smaller stands by:

- Excluding stock, and noxious pests from the woodlands, by fencing and APB methods.
- Survey the woodland areas with a botanist to identify the species diversity and rarity.
- Encourage regeneration through developing skilled burning techniques such as those carried out by Jack Mercer in the Tambellup Shire (see Appendices).
- Re-introduce into the woodland the missing species such as original understorey plants (see 2 below).
- Protect the Ngopitchup swamp, a site of special wetlands significance and high heritage value.
- Continue to investigate funding and alternative fencing (electric) opportunities that will hasten their protection eg. Remnant Vegetation Protection Scheme.
- Continue to condition score the native bush areas, to assist in setting priority for fencing, with help from CALM or specialists (University students at Curtin School of Environmental Biology), as a catchment field activity.

2. To regenerate degraded bushland by:

- Fence to control grazing.
- Treat soil so as to create seed and water traps.
- Control weeds.
- Introduce appropriate seed, if there is none left on site.
- Consider the careful use of fire to stimulate seed release and germination.
- Control insects if necessary.
- Monitor effects.

3. To prolong life of paddock trees and 'feature' clumps for shade and improve wildlife habitat by:

- Selecting special trees; significant tree clumps, trees ringbarked or "last" specimens.
- Pace out a 50 m circumference (16 m diameter) around trees or trees, mark off area with 8 pegs (6.25 m apart).
- Decide whether to plant seedlings or regenerate with fire and seed (if regenerating follow actions in 2 above).
- Erect fence and "Ringlock" (4 clumps can be protected with one roll of wire).
- When planting seedlings or thinning out direct seeded plants aim for at least 6 tall trees, 20 shrubs and as many groundcovers as possible.

4. To establish nature corridors along natural features such as creeklines, and established contour features such as windbreaks and grade banks by:

- Selecting major creeklines, fence and allow regeneration (see 2 above).
- Selecting large, blocks of bushland with a wide variety of tree and shrub species, and establish corridors on the most appropriate natural features.
- Consider the inclusion of dams with corridors, eg. along grade banks.
- Select minor gullies and fence to major creeklines, linking trees on banks or windbreaks to dams and large bush stands on hilltops.
- Establishing windbreaks and trees on grade banks to link up creeks and bushland areas (crest of hills, midslopes and on the flats).

5. To widen and thicken the vegetation on road reserves/verges for nature corridors by:

- Organising a drive-around to identify which road reserves will be expanded (invite a botanical expert)
- Negotiating with Shire and shift fencing 10 m inwards when they are due for replacement (if agreeable with landholders).
- Beginning a direct seeding planting program (aim for maximum weed control) with local species on wider areas and large previously weed infested gaps.

6. To protect and regenerate bushland on surveyed, unmade road reserves by:

- Organising a drive-around to identify which unmade road reserves should be rejuvenated with botanical expert.
- Confirm objectives with Shire. Seek their approval.
- Confirm objectives with adjacent landholders. Seek their approval.
- Fence both sides.
- Follow steps/actions in 2 above.

7. Co-ordinated annual fox control should take place by:

- Organise catchment get together in September to discuss APB control measures. (All group plus representatives from owners of public land in the catchment, CALM, Shire, etc.)
- Set up a baiting week (allows dogs to be chained up) in mid October using 1080 fresh meat baits (environmentally friendly) and mark sites discretely. Rule of thumb, one bait per five square kilometres.
- Retrieve all unused baits and bury them in a safe manner eg a one metre depth post hole.
- Follow up with an annual fox shoot (March) to remove residue foxes before main food source becomes plentiful (lambs).
- Record number of baits taken, and where they were taken. Record the numbers of foxes shot in the catchment.
- Celebrate for wildlife!

Native bush management on farms

The catchment has approximately only 178 ha of privately owned natural bush remaining, of which about 126 ha are still unprotected from stock.

Native bush is a resource of what naturally grows and is adapted to the Byenup soils and environment. Its preservation will have numerous benefits:

1. It serves as an on-farm or for sale, supply of fence posts (eg. split white gum for electric fencing), firewood, furniture, woodwork, and wildflowers.
2. It allows for a cheaper, more effective, time saving technique of establishing trees on farms through its regeneration, once protected.
3. It allows for production gains by cutting down the chill factor of wind for livestock, crops and pastures.
4. It is a record of native species for local soils. It is a habitat for local native wildlife and plant species.
5. It allows for increased bio-diversity of natural predators to insects and weeds that invade desired crops and pastures.
6. It is aesthetically pleasing as it blends with the landscape.
7. It is a good resource for local seed collection, for growing trees on-farm or for sale as seed or seedlings.
8. It increases land value.

Some additional points to consider

Where there are reasonable stands of vegetation in each of the land management units on individual properties:

Granite Hills

1. High level recharge areas, therefore should be left vegetated or be revegetated.
2. Some short rotation grazing potential eg. lambing and during sheep weather warnings.
3. Rabbits can be difficult to control. If grazing is not priority than a planned introduction of poison plants, eg. Box and York Road Poison can control rabbit numbers.
4. Check for native seed/flower production potential.
5. Site for seed tree plots, eg. tree lucerne.

Gravelly Ridges

1. This vegetation type is on the transition zone between Jarrah Forest (west) and Wandoo Woodland (east). Species dominance will change with annual rainfall.
2. It has a high conservation value, particularly for birds as a high percentage of south-west species are obligate nest hollow breeders. Also ideal for the several local species of bats (our unseen fauna!).
3. It has a high potential for minor forest produce, eg. firewood, fencing material, craftwood.

Marri Duplex Slopes

1. Pasture/cropping.
2. Revegetate gully heads for erosion/salinity control and link to other bush remnants as corridor for fauna movement.

Dykes

1. Original vegetation was probably Wandoo-Jam-Sheoak and possibly some York Gum.
2. May be worthwhile; investigation Sandalwood production if re-planting any areas.

Flooded Gum Gullies

1. *Eucalyptus rudis* should persist despite grazing pressure and thus may be given a lower priority in any immediate farm re-fencing program.
2. If unfenced for a long time in-filling by hand planting and protecting these individual trees with screens could be considered.

3. Earthworks for salinity/waterlogging control best upslope to minimise problems due to local flooding in very wet periods.
4. Machinery for earthworks should be clean of all dirt and soil before entering the property to avoid introducing fungal disease (eg. "Dieback", Armillaria) to tree plantings, shelterbelts and natural remnants.

Single Paddock Trees

Most of these are "sacrifice trees" as their natural attrition due to old age, wind buffering, fertiliser, chemicals, ring-barking, compaction, insect attack (lerps), cropping practices (deep ripping), sheep camps, dozey farm drivers, makes them unsustainable.

It is important to recognise their loss and replace their numbers in more desirable positions of the farm.

It has often been observed in the catchment that old stags, after they have died and broken off cause saline seeps as their old root system created a preferred pathway to the surface for groundwater (there is a good example on Korong Vale)

It is important to utilise the fallen trees quickly, using them for firewood, fence posts or for creating ash beds for direct seeding in desired regeneration areas eg. old white gum stands. (See details for "Wandoo regeneration" using ashbeds in the Appendices).

Creating shade and wildlife areas from single paddock trees

Mid-paddock shelter deserves more consideration when farm revegetation is planned for **shade**. Many people plant trees in individual guards in an attempt to imitate the park-like landscape which is achieved with majestic old trees dotted in paddocks. The difficulty with single trees is that the sole tree established within the guard is exposed to all the stresses which are afflicting lone trees, in an environment totally different from that in which the much-admired older trees grew up.

Two practical options to try

There are two alternatives to the planting of individual shade trees which should both be investigated.

Firstly, prolong the life of the paddock trees that are left and enhance them where possible with natural regeneration and establishment of understorey species. Initially it has been shown that removing dead or dying branches and **pruning** severely concentrates the resources of the tree on producing fresh growth. Then establish seedlings or direct seed understorey and replacement seed around single clumps or single trees.

The second option is to establish trees in small clumps, containing trees and understorey shrubs in a mutually supportive environment. They are more ecologically stable, they are likely to remain healthy for much longer than single trees providing better habitats for natural predators of insect pests, they are better protected from wind and allow for the natural genetic variation. They also will look more natural.

The diagram below is an "octagon shade clump" designed by a farmer in Victoria.

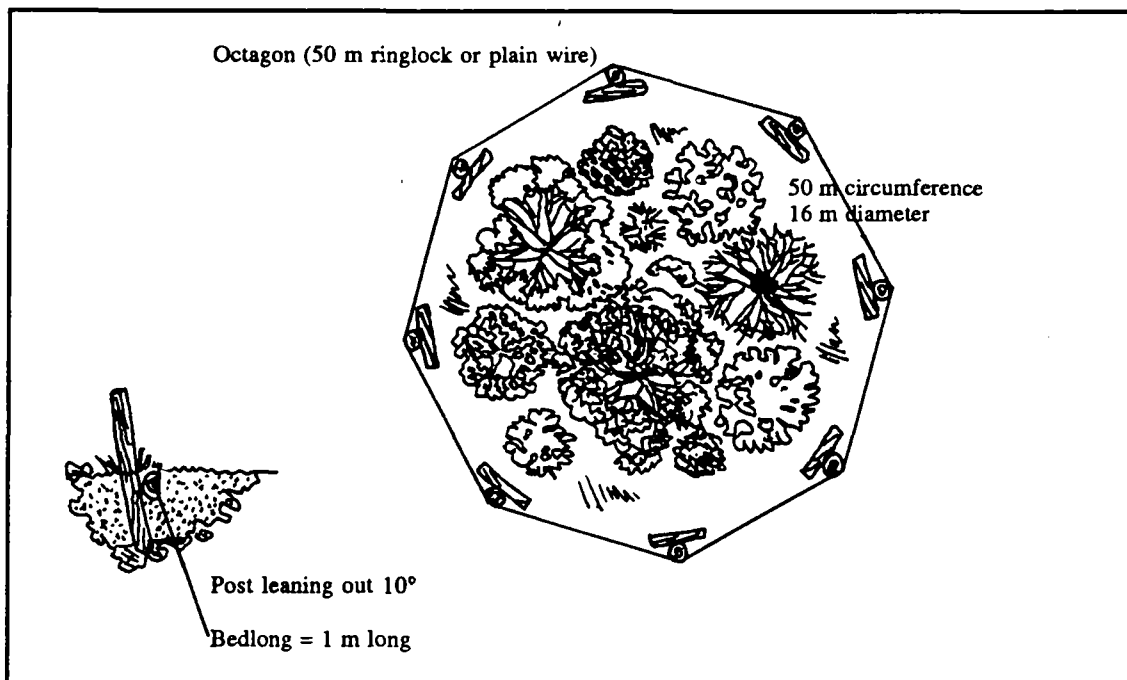


Table 1: Showing the farm distribution of bushland in the ten land management units in the catchment.

LMU (total of farm in catchment)	Farms						(Ha) Total
	'Crathie'	'Forts Valley'	'Korong Vale'	'Cranham'	'Dooledup'	'Barrule'	
Dolerite Soils	1.3	2.3	5.3	1.0	2.1	2.2	14.2
Salty gullies	6.1	15.2	3	0.6	1	12.9	38.8
Seeps	0.1	-	-	-	-	-	0.1
Deep sands	-	-	-	-	-	-	-
Gravelly Sandy Duplex	0.2	0.1	-	1.2	-	-	1.5
Granite Soils	-	11.1	47	0.9	-	4.7	63.7
Marri Duplex	1.2	4.7	29.5	0.9	0.2	10.8	1865.7
Flooded Gum Gullies	0.6	0.5	2.6	5.7	0.2	2.1	11.7
Alluvial Soils	0.8	-	-	-	-	-	0.8
Waterlogged	0.4	-	-	-	-	-	0.4
Total in Catchment (ha)	10.7	33.9	87.4	10.3	3.5	32.7	178.5

Dams For Wildlife

Most farm dams are constructed solely for water conservation. However most dams have the potential to become wildlife habitats as well, providing aesthetic and many other benefits to the whole farm.

The design of the livestock dams vary from the ideal for wildlife - the former generally should be deep with a small surface area, while the latter needs a large surface area. With planning, design and construction can be modified to suit all purposes.

The following points may help:

1. Vegetation is a primary attractant for wildlife. A perfect location for a dam is backing onto natural bushland. This will encourage its use by mammals and water birds.
2. Water quality is most important, especially if you are to stock fish. Sheep manure is the biggest pollution, so encourage sheep to camp at the back and the sides of the dam by planting trees on 3 sides only, rather than at the front.
3. Plant local species - they are better suited to the local conditions and the native birdlife.
4. Heavily flowering species provide nectar and hence insects. The attracted birds then benefit agriculture by keeping down pest numbers.
5. A wider variety of birds will be attracted to a dam where the vegetation is a mixture of species rather than the same kind. So when planting, aim for a variety of species to diversify the habitat.
6. Plant a mixture of tree sizes and shapes - don't forget the understorey which provides a habitat for ducks and other animals that can't get into the taller trees. Even grass provides a resting ground.

7. 30-50 m width of trees behind a dam is sufficient to provide shade and shelter for wildlife. Be sure to leave a clear flight patch for the water birds - ducks in particular like room to manoeuvre.
8. The dam wall should not be planted to trees as penetration by roots can lead to dam failure. However, grassing the walls provides habitat as well as preventing erosion down the batters.
9. Try to position some of the taller trees close to the dam so that they will eventually overhang and shade the water's edge.
10. Windbreaks around a dam reduce evaporation by at least 10%
11. Use silt traps or piped inlets to reduce the siltload in the dam. Even a fenced off grass filter strip of 1 ha immediately upslope of the dam mouth helps control sediment.
12. Direct water from the catchment to the dam by grade banks and plant a couple of rows of trees immediately down slope of the banks to provide small corridors for wildlife.

These measures, carried out at little cost will greatly assist some of the remaining wildlife in the catchment to survive.

Road verges and unmade roads

Roads are set aside for the movement of vehicles, however, the road verge is also a corridor for the movement of wildlife: lizards, insects and especially birds. Many verges are disjunct (ie. the vegetation is not continuous enough to allow that movement). Sudden changes of vegetation types will interfere with movement, for example, from a jam/sheoak mix to wild oats and weeds.

Consideration should be given to widening all road reserves and double fencing the closed roads so that they can be regenerated to provide a continuous line of perennial vegetation. There are 16.7 km of road reserves, 14 km of unmade roads (mostly open to stock). The benefits of such a proposal would include:

1. Corridors provide for the continuous movement of wildlife, especially birds.
2. Corridors act as linkages between larger areas of remnant vegetation.
3. Reduction of fire hazards in weeds.
4. A better looking environment.
5. "Safe" areas in which to plant trees without fear of destruction by stock to help in the overall stabilisation of the environment.
6. Windbreaks and water use.

The concept could be put into place over a long period. One method could be:

1. Get together and decide which road verges will be expanded. (The better suggestion is to move fences on one side of the road only, eg. inwards for 10 metres, rather than sides for 5 metres.)
2. Get together and decide which unmade roads are worth double fencing (check catchment map). Approach the Shire for permission to close road off and revegetate.
3. The fence is shifted inwards 10 metres when it is due for replacement or earlier if desired on roads.
4. The site is sprayed for weeds, then a busy bee planting program (perhaps a school group) would plant indigenous species, in particular Sheoak, Marri, Redheart, Jam and Jarrah.
5. The plan could be installed over 10 to 20 years depending on the boundary fence replacements.
6. Encourage Shire to be cautionary when grading road edges.

If the total length of road in the catchment area 16.7 km was done, there would now be 23.3 hectares taken up by the expanded verges. If the total length of 14 km unmade roads in the catchment were done, there would be 18 ha of nature corridors protected. After a survey of road verges, one might find that there would be many hectares less requiring full treatment.

Weed control on public land

Weed control with chemicals is a complex issue on public land such as road verges and reserves. It is recommended that landholders concentrate on treating their own properties first. The best technique however is by manual 'grubbing' weeds. This can be rewarding if small target areas are worked on first. Also it ensures only the weed is removed, not adjacent native species that are often caught in spraying too.

Chemical control treatment on public land must be done by licenced operators eg. APB and private spraying contractors due to the Public Health Act. This restricts spraying from private enthusiasts and the Shire operators (unless licenced).

Biological control, as an alternative to spraying weeds in the catchment needs investigating, for instance biological control is being screened for in South Australia for Bridle Creeper.

Productive weeds

Many invasive weeds such as veldt grass, tagasaste and phalaris have a high productive value for grazing (see perennials). If they are managed well, in the paddock, then there is no reason for them to become a 'noxious' plant species.

With good bushland management (see above), grubbing specific plants improves the bush quality including the understorey species, then weeds have less opportunity to invade and survive. This is also a management technique to reduce the fire hazard of protected bush areas.

Native cut flowers as an alternative income and land conservation

Wildflower cultivation has a potential in all the sub-catchments of the Carlecatup catchment. Many farm plans have highlighted the hazardous soils under current rotations, the deep sands, the deep sandy phase duplex soils, seepage areas, well drained rocky areas, fresh swamps and even the smaller isolated areas of productive, well drained soils. Wildflowers are a commercial, alternative for these areas. Numerous farms in the Northern Wheatbelt have already established productive stands of wildflowers. In fact, wildflowers have been a commercial crop for over ten years. In 1991/92, Western Australia exported \$15.5 million of cut flowers. As well as this economic attraction, wildflowers have a number of land conservation values. They help preserve our genetic resource, promoting seed collection, increase *water-use*, increase profitability on low production land and have an enormous potential to increase the nature conservation value to a property or catchment.

Set up a demonstration or trial area

As a catchment group the objective of investigating alternative high value crops has often been discussed. To begin with a number of trial plots need to be established with close consultation with advisers. This would provide expert input as well as an opportunity to experience the management features for a successful wildflower enterprise. The co-operative approach of the catchment group to getting started, marketing, processing and freight also offers many cost-sharing benefits (in the long term).

The prerequisites to starting will depend on the **capital** needed to support the venture until it generates income, some three to four years for most native species. However this is considerably shorter than returns for trees for commercial use. Also good **business** management skills are needed rather than just the love of wildflowers. The **technical** expertise of an adviser will also have to be developed. Particularly as cultivation of wildflowers is a relatively new industry. Ultimately there is a lot of **labour** required. Therefore it would be sensible to start with a small trial area. The early, main species selection decisions must consider 'timing' of flowering of the wildflowers (for harvest) with the other activities on the farm. *Give it a go!*

Tips for species selection

In the Carlecatup Catchment area whether a soil drains well or not will determine the species selection. For a non saline summer moist or swamp site some species of Ti tree (*Agronis*), Myrtles (eg *Scholtzia*), Swamp Daisy (*Actinodium*) and Boronia may suit; for well drained sites, some species of Ispogon, Smokebush (*Conospermum*), Bookleaf (*Daviesia*), Dryandra, Banksia and Protea may suit. Apart from the soil type and its drainage other important features that determine suitable species for a site are; the wind protection, the risk of frosts, salinity of soil and water, fertiliser history, presence of root fungi in the soil especially Phytophthora cinnamoni (Jarrah Dieback) and the capability of setting up summer irrigation to the plantation such as a trickle system.

Tips for layout

Site layout will consist of in-row spacings depending on the plant at maturity. Also the rows will need to allow vehicle access for pruning, harvesting and spraying once the plants are mature. Autumn through to early summer is the best time of year to plant, depending on how low the winter temperatures are. Planting is with

seedlings and similar to tree planting. The site should be completely prepared including the irrigation so that plants are well watered during planting.

There is plenty of technical advice and experience available from the Department of Agriculture, including Farmnotes (see appendix). Aileen Reid, Extension Officer in the Division of Horticulture, South Perth is available to assist establish and manage a wildflower enterprise in the catchment. She would be a good resource person to help establish some small plots on farms in the catchment.

Fox Control

The numbat case study

A survey by CALM at Dryandra in 1979 showed that numbats were hanging on in very low numbers. In the 1950's studies showed that there were three numbats in each 100 kilometres (of driving slowly around the tracks). The 1979 rate was 0.2 per 100 kilometres. A number of factors were examined that might have caused such a drop in numbers. The effect of predation was the most dramatic factor.

An experiment was carried out between 1982 - 85 to determine what effect this predation was having on the numbat population. Two areas of the forest, of about 20 square kilometres were surveyed for numbats. A fox baiting program in one of the areas effectively removed all foxes and prevented them from re-establishing. Further studies three years later showed that numbat numbers in the unbaited area showed little increase, but rose dramatically in the baited area. Further work by CALM in 1990 showed that rock wallabies and woylies, tammars and possums also increase in number when foxes are removed by baiting.

See Outcome and Actions 7 above, October baiting has greater efficiency, one bait will potentially remove the vixen plus all suckling cubs. This period is when fox populations are most territorial. In summer months foxes travel greater distances and are less territorial.



Existing vegetation on creeklines, unmade roads, paddock clumps and single trees — which to protect first?

1. Birds seen on or around 'Forts Valley', Kojonup
by Maree Bilney and Wayne Zadow

Pacific Black Duck	<i>Anas superciliosa</i>
Stubble Quail	<i>Coturnix pectoralis</i>
1 Spoonbill	<i>Platalea flavipes</i>
Australian Shell duck	<i>Tadorna tadornoides</i>
Crested pidgeon	<i>Ocyphaps lophotes</i>
Common bronzewing	<i>Phaps chalcoptera</i>
Pink and grey galah	<i>Cacatua roseicapilla</i>
Black cockatoo	
Red tailed black cockatoo	<i>Calyptorhynchus magnificus</i>
Purple crowned lorikeet	<i>Glossopsitta porphyrocephala</i>
Regent Parrot	<i>Polytelis anthopeplus</i>
Red capped parrot	<i>Purpureicephalus spurius</i>
28 parrot	<i>Platycercus zonarius</i>
Elegant parrot	<i>Noephema elegans</i>
Laughing kookaburra	<i>Dacelo novaeguineae</i>
Scared kingfisher	<i>Halycon sancta</i>
Barn owl	<i>Tyto alba</i>
Tawny frogmouth	<i>Podargus strigoides</i>
Red capped robin	<i>Petroica goodenovii</i>
Scarlet robin	<i>Petroica multicolor</i>
Willy wagtail	<i>Rhipidura leucophrys</i>
Grey fantail	<i>Rhipidura fuliginosa</i>
Splendid wren	<i>Malurus splendens</i>
Yellow rumped thornbill	<i>Acanthiza chrysorrhoa</i>
Singing honeyeater	<i>Lichenostomus virescens</i>
Maggie lark	<i>Grallina cyanoleuca</i>
Butcherbird (pied)	<i>Cracticus nigrogularis</i>
Grey Currawong (clinking form)	<i>Strepera versicolor</i>
Western magpie	<i>Gymnorhina tibicen</i>
Australian raven	<i>Corvus coronoides</i>
White faced Heron	<i>Ardea novaehollandiae</i>
3 Wedgetail eagles	<i>Aquila audax</i>
Australian Little Grebe	<i>Tachybaptus novaehollandiae</i>
Black faced Wood Swallow	
Western Silver Eyes	<i>Zosterops lateralis</i>
Pallid Cuckoo	<i>Cuculus pallidus</i>
Black Fronted Plover	<i>Elanus notatus</i>
Black Shouldered Kite	
Nakeen Kestrel	<i>Falco cenchroides</i>
Curlew (2 at Mathwins)	
Brown Honey Eater	<i>Melithreptus brevirostris</i>
Welcome Swallow	<i>Hirundo noexena</i>
Tree Martin	<i>Cecropis nigricans</i>

2. Ngopitchup Reserve by Wayne Zadow, May 93 during a 2 hour observation.

Grey Strike Thrush	<i>Colluricincla harmonica</i>
White-Browed Babbler	<i>Pomatostomus superciliosus</i>
Raven	<i>Corvus coronoides</i>
Western Magpie	<i>Gymnorhina tibicen</i>
Maggie Lark	<i>Grallina cyanoleuca</i>
28 Parrot	<i>Platycercus zonarius</i>
Western Rosella	<i>Platycercus icterotis</i>
Mountain Duck	<i>Tadorna tadornoides</i>
Maned Duck	<i>Chenonetta jubata</i>
Singing Honey Eater	<i>Lichenostomus virescens</i>
Brown Honey Eater	<i>Lichmera indistincta</i>
Brown Headed Honey Eater	<i>Melithreptus brevirostris</i>
Tree Martin	<i>Cecropis nigricans</i>
Red Wattle Bird	<i>Anthochaera carunculata</i>
Painted Quail	
Grey Fantail	<i>Rhipidura fuliginosa</i>
Black Capped Sitella	<i>Daphoenositta chrysoptera</i>
Splendid Wren	<i>Malurus splendens</i>
Golden Whistler	<i>Phacelops pectoralis</i>
Willy Wagtail	<i>Rhipidura leucophrys</i>

Dusky Wood swallow
Western Warbler
Yellow Tailed Thornbill
Western Thornbill
Broad-tailed Thornbill
Striated Pardalote
White-naped Honey Eater
Western Yellow Robin
Rufous Tree Creeper
Red Capped Parrot
Rufous Whistler
Laughing Kookaburra
Black-faced Woodswallow

Gerygone fusca
Acanthiza chrysorrhoa
Acanthiza inornata

Pardalotus striatus
Melithreptus lunatus
Eopsaltria australis
Climacteris rufa
Purpureicephalus spurius
Pachycephala rufiventris
Dacelo novaeguineae
Artamus cinereus

3. Also, the Eurasian Curlew is an occasional visitor to Barrule

This is not a definitive list, but rather a basis for further additions.



Degraded Meleleuca sp. in an unprotected river bed



**Vast quantities of silt deposited on lower catchments
from upper slopes will cause flooding**

OBJECTIVE 4

To demonstrate a *catchment planning method* for protecting and enhancing the productivity of agricultural land.

Introduction

The actions listed below are in a sequence that were taken by the farmers in the Byenup Hill Catchment. They are recorded so as to be a **guide** for future groups interested in treating land degradation within a catchment. The rate and direction of planning will vary. It is also recognised that each catchment will have its own priority elements that dictate what the emphasis will be in their plan.

The actions below are necessary to quantify the resources in the catchment; gather together technical information on the catchment; share experiences; attract expertise and resources, so that the group is better prepared to plan and to keep reviewing/adjusting the plan.

Outcomes and Actions

1. To get the group together and resolve a commitment to work together to improve the farming systems in the catchment by:

- Approach the Land Conservation District Committee (if they have not already approached you) with a proposal to prepare a plan.
- Get together as a group (with refreshments); elect a co-ordinator and catchment name; develop a list of what land degradation exists; identify work being done already; brainstorm some new ideas for the first 12 months.
- Take a 'cooks' tour (bus) around the catchment with an 'expert' of your choice and invite a farmer from another already "up and running" group to talk about their approaches. (Think about visiting another catchment nearby too).
- Order aerial photographs and enlargements for each property and a laminated topographic map of the catchment. Purchase an enlarged aerial photograph showing the whole catchment at a manageable size/scale. All from the Department of Land Administration, Perth.

2. To have every farm with a completed farm plan in the catchment by:

- Invite a Department of Agriculture (DOA) Project Officer or soil specialist to site back-hoe soil pits on the land management units for a field day. This day will ensure everyone is familiar with the units (in the paddock) before the mapping.
- Nominate your group for farm planning workshops with the Department of Agriculture and follow up farm visits (optional) that come at the completion of the sessions.

3. To prepare the Catchment Plan as a series of maps and supporting report by:

- If funds 'allow' have the farm plans digitised on GIS or otherwise transfer the individual farm information by hand onto the catchment aerial photograph. This will provide a good convenient planning tool for later. However the GIS option it is able to 'merge' individual plans together to a catchment scale (as with Byenup Hill catchment)
- Get together as a group and discuss the 'new' expectations and priorities for the catchment plan. Invite the Project Officer or member of the DOA to attend.
- Invite DOA planning group back to assist in developing a catchment perspective with the compiled catchment information that is on overlays (either hand drawn or by GIS).
- Document into a report all the **quantities (eg. hectares of cropping LMU, kilometres of creeklines, etc)** of catchment 'resources'.

- Invite 'experts' (of your choice, eg. Project Officer, Hydrologist, etc) to prepare a new overlay that outlines the practical recommendations for revegetation and other treatments necessary for the catchment (by ignoring farm boundaries). Also include their ideas, as supporting chapters in the catchment report.

4. To review and modify the farm plans after the catchment recommendations have been presented by:

Individuals to review their plans at a get together. Based on the new ideas about the catchment given by the 'experts'. Then set up implementation steps as a group.

5. To set up catchment monitoring points to evaluate, landscape changes by:

- Identifying point-sources to monitor and record the quality of surface and groundwaters in the catchment.
- Identifying on the ground photograph sites using reference posts for annual photograph records in the catchment.
- Identifying monitoring point sources to assess pasture density and dry matter yield per hectare in winter and summer and for crops (yield per hectare) at harvest on the key land management units.
- Review and invite comment on the monitored records, from 'experts'. Adjust plans with the changing environment and the market forces.

6 To investigate new technologies and implement changes in land management that have the potential to increase productivity or our understanding of how the landscape processes are still affecting productivity by:

- Invite specialist experts to speak, demonstrate, and test new innovations such as airborne (or ground) geophysical surveys, satellite imagery and groundwater maps in the catchment.
- Capture new resource information on GIS and prepare a new "overlay" of this information.
- Review and adjust the catchment and farm plans.
- Invite specialist advisers/researchers to investigate alternative farming systems that may provide alternative income, (eg. Eucalyptus oil, wildflowers, etc), add value to existing products (eg. increasing crop rotations, minimum tillage), low cost farm improvement (eg. machinery modifications), increasing plant diversity (eg. including native vegetation), provide long term perennials (eg. commercial sawlog timber) and less reliance on chemicals (eg. grazing manipulation).
- Review and adjust the catchment and farm plans. Set 12 monthly implementation targets.

CATCHMENT PLANNING WITH THE BYENUP CATCHMENT

1. The first get together of the group (see Outcomes and Actions No. 1) produced the following ideas taken from notes of this meeting.

**Byenup Catchment Group
Meeting held - Thursday 7th December 1989**

Land degradation problems?

1. Water erosion - wash aways from firebreaks and cultivated land.
2. Wind erosion - an under-rated problem, particularly in the autumn months.
3. Salinity - in low lying areas
- seeps higher up slopes.
4. Waterlogging - widespread
- rated as a seasonal problem affecting crops only
- identified in areas separate to saline areas.
5. Freshwater seeps - not a problem due to the low numbers involved.

Comments:

- a) pastures aren't using enough water
- b) shallow rooted
- c) fodder shrubs, hard to manage
- d) waterlogging affects the amount of cropping
- e) drainage would help, but cost is high.

Greatest threat?

Salinity is considered the greatest potential threat, although not a major problem at the moment.

Although waterlogging is the most widespread problem it is only seen early in the season as a problem or after heavy rain.

Degradation of soil structure affecting infiltration rate of rainfall.

How do you feel about this ?

Salinity wasn't seen as a big problem at that time. Similarly control measures were given a low priority as there are not short term benefits. Somebody made the comment "that control measures for salinity were more of a hobby." However, it was recognised that the longer the problem was left the worse it would become.

Having a long term plan was mentioned as a possible solution.

The biggest worry was that salinity was increasing (slowly) every year.

Problems on neighbouring farms?

Generally everyone acknowledged problems on neighbouring farms and also appreciated that they might be contributing to them. Difficult to justify control measures on a farm purely for someone else's benefit.

How can we link these problems? (Solutions)

A catchment plan was seen as the most effective way of solving the problem. Commitment to the long term adoption of the plan was also important. It was made clear that the plan would recognise the priorities of individuals with farm plans ranked above catchment plans.

Recharge areas will need to be identified for strategic tree planting. Sharing of costs between farmers where they both benefit from an activity is to be encouraged.

It was agreed that an inspection of the catchment by an outsider would give an objective view point to the plan.

Catchment objectives and activities ("review" every twelve months)

To get to know the catchment:

- Group meetings with discussions
- Catchment tours
- Flights over the catchment (+ LCD)
- Viewing of the Potter Farm video
- Visit to the North Stirling LCD to look at farm plans and perennial pastures.

To develop the farm plans:

- Purchase of aerial photographs
- Prepare the aerial photographs, "LMUs", "existing works", and "proposed works" on overlays (workshops).
- Prepare and correct farm plans during final digitising on GIS.
- Prepare funding applications for broadacre perennials demonstration (successful 1992).
- Prepare funding application for materials to fence sections of the creeklines (to be confirmed - 1993).

To implement "works" on the ground:

- Plan and implement individual on-farm projects (involving drains, trees, perennials, fencing and establish piezometers).
- Direct seeding of Eucalypts and understorey in a windbreak.
- Tree planting on various sites (annually).
- Fencing to LMUs (ongoing)

To raise awareness and publicise activities:

- Picnic at Yedibirrup Rock
- Articles in the Carlecatup Newsletter/ Kojonup News.
- Reports at LCDC AGMs
- Public launch of catchment/farm plans.

- | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>2. As the farm planning got underway with the group (see Outcomes and Actions No. 2) the soils were inspected, the landform pattern, vegetation, geology, management considerations, potential to degrade (limitations) and potential to produce, were all discussed on the travels around the catchment. The following is an extract from the field notes.</p> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Carlecatup LCD Field Day - Monday 25th March 1991 Byenup Catchment

Field Day Schedule

1. Identifying and mapping Land Management Units (LMU)
2. Map of LMUs
3. LMU chart
4. Soil descriptions
5. Space for taking notes.

Identifying and mapping LMUs for farm planning

The objective is to focus on LMUs in the catchment. This follows on from having already mapped the "natural" features of your property on your aerial photograph enlargement (1:10,000 scale) and developed a "contour" overlay. A second overlay of the "existing fencing" separating it from the base photograph information has been completed.

The LMUs that we have identified are based on sloped classes, soil types, and their capabilities. These units have already been mapped from 1:15,000 and their identifying features are described in the schedule and in the field (soil pits). It is important that these are representable and recognisable to everyone. It should then be possible to develop the 1:15,000 map of the LMUs into a more detailed pattern on your 1:10,000 property plan. If you have some doubt of the location of the boundaries on your property then these should be checked by visiting the paddock and keeping an eye open for the identifying features.

Sometimes two soil types may occur together in a very complex pattern and may have to be mapped as one unit. As you work it is worthwhile mapping areas of waterlogging, saline seeps, salinity or erosion.

Future farm planning for catchment groups

The Byenup Catchment plan will consist of resource maps and a document of management recommendations and will be available for general use in 1993. This will be a useful resource for future farm planning in sub-catchment groups in the Carlecatup Catchment. It is hoped that an Open Day to launch this plan will be organised.

3. The following sessions were then run in the early evenings to get the compiling of information and planning underway.

Byenup Catchment Field Day

Farm Planning Session 1 - Monday 25th March - Thursday 16th August 1991

A procedure to follow for recording the natural features of your farm using the aerial photograph enlargements.

Using your aerial photograph as a base mark on the following using china graph pencils:

<i>Feature</i>	<i>Colour</i>	<i>Code</i>
Property boundaries	Solid	line
Major creeks and waterways	Solid	line
Minor creek drainage depressions	Dashed	line
* Internal fencing	Solid	line
Laneways	Solid	line
Existing vegetation as from today (1990)	Solid	line
Established tree lot/windbreaks		
Existing dams and roaded catchment (indicate the overflow from dams)		
Permanent access tracks	Solid	line
Names of roads		
Paddock names/numbers and landuse	No 1/"Cow"	
	1:6 Wheat/Annual Pasture	
* Culverts Floodways		
Aerial photograph scale		0 200m
	For example: 1:10,000 Scale 1cm:100 m	
North direction	N ↑	

Additional Notes

Feel free to make notes on the aerial photograph eg. ideas and problems. These will become the basis of future overlays. You may find it easier to work with the photograph secured temporarily to a hard board.

Following sessions (half day)

The following sessions will involve:

- No. 2 * Preparing overlays of natural resources; major landforms and soil types.
* Existing vegetation
* Identification of land management units (Stereoscopes will be available).
- No. 3 * Preparing overlays of hazards and limitations;
eg. water erosion, salinity etc.
* Landuse details;
eg. type of crop rotations, pastures and other landuse options, such as tree planting.
* Earthworks;
eg. modification of drainage lines, banks etc.
* Commence altering the farm layout - Draft plan.
- No. 4 Finalising the farm layout.

With assistance from additional Departmental advisers and economist.

During these sessions guest speakers will highlight special topics of the planning process.

In summary

The procedure outlined above was followed by the Byenup Catchment group. They have now progressed to Outcomes and Actions No. 4. It became obvious that the initial draft plans were not static (even up to the third attempt at completing the final 'proposed works' overlay). This confirms that a farm plan is best prepared by the farmer (with assistance). For, to prepare a farm plan properly, it is necessary to know what the land is like at all times of the year.

The primary approach of the farm and catchment planning process was for the farmers to document what they know about their land, and more importantly what they don't know, as a spur to find out more information and the significance of this information. It may continue to delay the start of works, but it ensures that the works are based on the best information available. Also it exposes the group to new information and encourages a desire to seek new information.

The value of the process of farm and catchment planning is illustrated by the number of new ideas incorporated into farm plans in the catchment, and the cohesion of the farm plans when aggregated to the catchment scale.

"There are two ways to measure the worth of a plan - by the changes it engenders inside the head and the resulting changes on the ground."

It became clear that the method of compiling, representing and storing information did not matter, provided it improved the general understanding of the land and of their impact of farming on it; that it facilitated better planning and decision - making about landuse, and that it leads towards a more sustainable use of the land.

Further reading: "Planning for Sustainable Farming" by Andrew Campbell (Lothian).

OBJECTIVE 5

To regularly *monitor*, record and review the productivity of the agricultural plants, native plants, the watertables and water quality in the catchment

The main reason for doing **monitoring** is to detect whether there has been any change and at what rate. Measurements taken over a period of time can be used to predict what is going to happen in the future. Monitoring therefore is a very useful tool in making management decisions. Monitoring takes place at the on-farm level and at a catchment level.

The main reason for **reviewing** progress is to strengthen the commitment to make landuse changes. A review will entail getting together on an annual basis, to discuss "works" put in place during the last twelve months and "proposals" for the next twelve months. It is important that some dates are set for 'work' and activities of catchment interest, and the persons initiating them are recorded. The "get togethers" should be eventful (light hearted) and social occasions. All of which will help ensure purpose and progress.

There is potential to store and record information on a paddock basis on each farm in each year of development of the plan. The information can be put onto the farm computer. A user-friendly data-base called "Landkey" is available to do this with the farm plan (when digitised) on the computer screen. Simply put, "this data-base sits behind your farm map on the screen of your computer."

Outcomes and Actions

1. *Set up a "Landkey" data-base for paddock records each year by:*

- Inviting the Department of Agriculture to install and demonstrate "Landkey" on farm computers, to include:
 - i) Land degradation changes (wind erosion, water erosion, waterlogging, soil salinity, soil fertility, silt loads, soil acidity).
 - ii) Water table records, levels and quality.
 - iii) Farm soil tests, rotations, cereal yields, pasture performance (see Pasture Watch) and stocking rates on specific sites on the farm.

2. *Set up a specific-monitoring points for the catchment and install "Landkey" to record them by:*

- Inviting the Department of Agriculture to install and demonstrate "Landkey" on farm computers to include:
 - i) Surface water quality and flow rates
 - ii) Bird lists
 - iii) Mammal lists
 - iv) Comments on photographic records.
 - v) Water table levels.
 - vi) Number of kilometres of different earthworks and comments.
 - vii) Number of hectares of different revegetation types and comments.
 - viii) Number of hectares of crop, pasture, perennials in the catchment and comments.

3. *Meet and review implementation on a 12 monthly basis.*

- i) Discuss effectiveness (invite an outsiders view).
- ii) Discuss changes and new ideas emerging.
- iii) Modify catchment priorities, and modify farm plan.
- iv) Arrange for proposed works overlay and other changes to be made through most available GIS microstation.

Photographic records

An extensive photographic record of the catchment using 35 mm colour slides and prints should be compiled. These photographs should be catalogued by farm and by subject material - for example, "creekline revegetation", "land degradation", "aerial flights", "farm layout", "bushland management" and "on-farm revegetation." These photographs should be re-examined at the annual reviews. Also they are useful for PR events.

Position a marker (star picket with a triangular plate welded to its top, to position and aim a camera) to maintain a consist direction for on-going (annual) photography. This will provide information on environmental changes, eg. before and afters, see suggestions for sites on catchment map.

Silt deposits

Monitoring silt deposits in a stream bed can be done very simply by measuring the average height of the silt in the creekbed from a fixed point using a level and staff.

Measurements gained over time will give an indication of the amount of water erosion happening in the catchment. It will also determine whether treatments in the catchment are working.

This style of monitoring is subject to many variables such as the silt being totally flushed out of the creekbed due to a major flooding event. However it is a more objective way of observing what is happening in the creekbeds and will increase the awareness of land degradation in the catchment.

Monitoring watertables

High in the catchment where there is plenty of relief the threat of salinity is not as great because the steeper slopes give surface water less time to infiltrate and keep sub-surface flows moving (unless there are restrictions, often causing hillside seeps). However, rising watertables, wether perched or true groundwater, have begun to effect confluence areas of streams in the catchment. Confluence areas are where two or more streams join but are also areas where sub-surface flows of water are concentrating hence rising watertables.

In farming, much use has been made of 3 m deep observation wells for monitoring of saltland to predict or determine whether the saline area is spreading or not. For an easy outline of how this is done refer to Farmnote 87/85 "A simple way to monitor your saltland". Soil testing is another form of monitoring periodically done by farmers to determine the nutrient status of their soils. Results from the tests help make important management decisions in obtaining the best production from each paddock in the coming year.

Observation wells on hillslopes monitored after rainfall events will give an indication of the rate and volume of sub-surface flows. There will be differences in rate and volume measurements with change in soil type and slope. Areas above confluence points in the streams with high sub-surface flow rates and/or volumes should be managed to reduce the sub-surface flow (e.g. trees, interceptor drains, high water using crops, perennials).

Valleys of the Catchment, particularly at confluence areas and areas where there is still natural existing vegetation, should be monitored with observation wells so that a check on the watertable can be kept and preventative action taken place before it is too late.

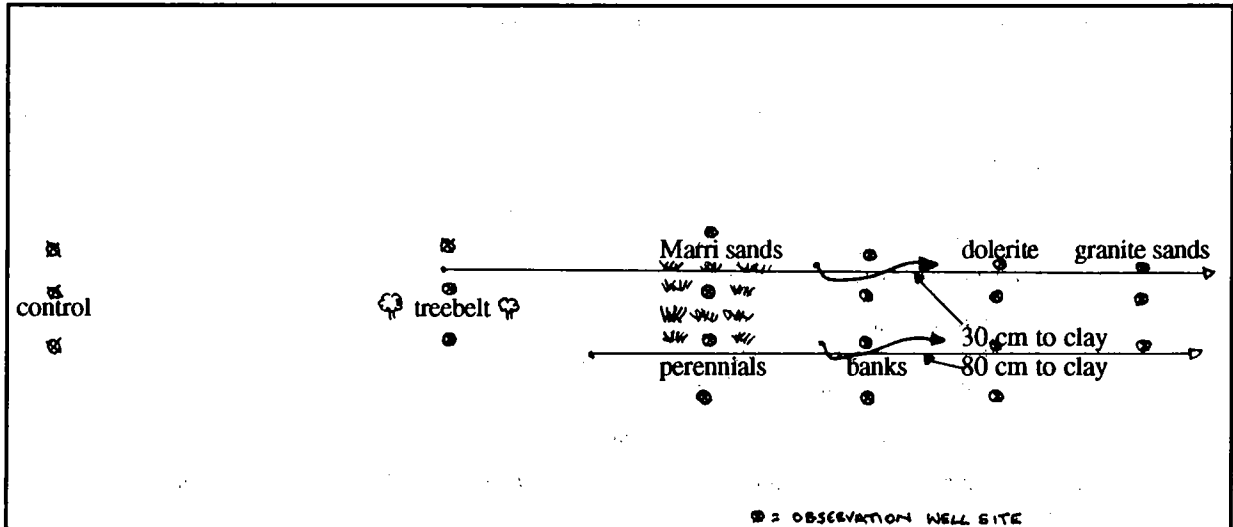
Despite the threat of salinity not being as great in the upper catchment there is still good reason to be aiming at using as much water as falls and infiltrates the soil. Water which is not used up by plants passes into the groundwater system. The groundwater flow is towards the lower catchment where watertables are rising and are already causing salinity. The upper and lower catchments therefore are inter-connected by both the surface and ground flows of water. Water control and use in the upper catchment will have an effect in the lower catchment.

Cost

As Farmnote 87/85 describes the main costs of installing observation wells will be the hiring of a drilling rig and the cost of materials. PVC pipe which is normally used is between \$4.00 and \$5.50 a metre depending on the diameter of pipe however just recently farmers have found a way of cutting material costs considerably. Black polythene pipe 40 mm in diameter and bigger will do the same job at half the price of PVC and usually it is the sort of thing that is left over from other jobs.

Recommendation

A demonstration site should be set up in the catchment to monitor the sub-surface movement of water under the different regimes of tree belts, perennials, banks and a control.



The Marri duplex either bare or cultivated is very prone to all forms of water erosion, because the sandy topsoil has low cohesiveness when wet, resulting in lower productivity of soils and silting of streams. Run-off from these slopes would also be a major contribution to the total volume of flood water in a storm event because of this soil unit covers the largest area of the catchment. By protecting these slopes with a grade bank system the peak flows will be reduced thereby reducing the erosive force of waters and the amount of channel erosion occurring lower down in the catchment.

Further reading: Farm Monitoring Handbook by Hunt and Gilkes, UWA press. (Available through the Land Management Society).



Silt build-up blocking culverts on Graham's Well Road at the bottom of the catchment

APPENDICES

APPENDIX 1

Water balance - volume calculations

Total size of catchment = 3200 hectares (32,000,000 m²)

Total average rainfall = 478 mm (0.478 m)

i.e. Total volume falling each year: $32 \times 10^6 \times 0.478 = 15,296,000 \text{ m}^3$

(i.e. 1.53 million cubic metres).

1. Continuous crop on the 'Gravelly sands'

(i) 765 hectares includes: Water use m/year

383 ha wheat (170 day growing season) = 0.306

191 ha lupins (170 day growing season) = 0.374

191 ha canola (170 day growing season) = 0.408

therefore: wheat total volume used = 1,171,980 m³/yr

lupins total volume used = 714,340 m³/yr

canola total volume used = 779,280 m³/yr

Total used 2,665,600

15,296,000 - 2,665,600 = 12,630,400 m³/yr unused which leaves 82.6% of the rainfall falling in the catchment.

(ii) Continuous pasture on remaining 'Gravelly sands', not in crop (765) ha or trees (60) ha

1146.5 hectares (1.6 mm/d over 180 growing days)

i.e. 288 mm/y (0.288 m/year)

0.288 x 1146.5 mm = 3,301,920 m³/yr total used

therefore 12,630,400 - 3,301,920 = 9,328,480 m³/yr unused which leaves 61% of the rainfall falling in the catchment.

(iii) Continuous pasture on 'Sandy loam' not in trees (32 ha)

726.4 ha (1.6 mm/d over 180 growing days)

i.e. 0.288 x 726.4 = 2,092,032 m³/yr

therefore 9,328,480 - 2,092,032 m³/yr = 7,236,448 m³/yr which leaves 47.3% of the rainfall falling in the catchment.

2. Perennial pastures

(i) Perennial pastures on 'Marginally saline land' not in trees (20 ha)

169.1 ha (0.8 mm/d x 365 days)

i.e. 0.292 x 169.1 = 493,772 m³/y

therefore 7,236,448 - 493,772 = 6,742,676 m³/y which leaves 44% of the rainfall falling in the catchment.

(ii) Perennial pastures on 'Waterlogged soils' not in trees (25 ha)

248.7 ha (0.8 mm/d x 365 days)

i.e. 0.292 x 248.7 = 726,204 m³/yr

therefore 6,742,676 - 726,204 = 6,016,472 m³/yr which leaves 39% of the rainfall falling in the catchment.

- (iii) Tagasaste and perennials on 'Deep sands'

8.8 ha (1.6 mm/d x 365)

i.e. $0.584 \times 8.8 = 51,392 \text{ m}^3/\text{yr}$

therefore $6,016,472 - 51,392 = 5,965,080 \text{ m}^3/\text{yr}$ which leaves 38% of the rainfall falling in the catchment.

3. Native bush, reserves, private bush, verges and unmade roads

221.4 ha (4.4 mm/d x 365)

i.e. $1.606 \times 221.4 = 3,555,684$

therefore $5,965,080 - 3,555,684 = 2,409,396 \text{ m}^3/\text{yr}$ which leaves 15.7% of the rainfall falling in the catchment.

N.B. Equates to 149.5 hectare of Wandoo woodland being required:

as: $5.7\% \times 15,296,000 \text{ m}^3$ (total volume)

$= 2,401,472 \text{ m}^3/\text{yr}$

i.e. Wandoo using 4.4 mm/d = 1606 mm/yr

$2,401,472 \text{ m}^3/\text{yr} + 1.606 \text{ m/yr}$

$= 1,495,312.6 \text{ m}^3$

$= 149.5 \text{ hectares}$

4. Tree plantations - distributed over the catchment

- (i) 48 kilometres of 3 row windbreaks (15 m wide) in cropping and pastures

72 ha (*E. maculata*, 6.4 mm/d = 2335 mm/yr)

i.e. $2.336 \times 72 = 1,681,920 \text{ m}^3/\text{yr}$

$2,409,396 - 1,681,920 = 727,476$ which leaves 4.7% of the rainfall falling in the catchment.

- (ii) 25 hectares of wide spaced Eucalypts on 'Waterlogged soils'

25 ha (*E. camaldulensis*, 1.6 mm/d = 584 mm/yr)

i.e. $0.584 \times 25 = 146,000 \text{ m}^3/\text{yr}$

$727,476 - 146,000 = 581,476$ which leaves 3.8% of the rainfall falling in the catchment.

- (iii) 20 hectares of salt-tolerant Eucalypt and Acacia strips on 'Marginally saline land'

20 ha (1.6 mm/d = 584 mm/yr)

i.e. $0.584 \times 20 = 116,800$

$581,476 - 116,800 = 464,676 \text{ m}^3/\text{yr}$ which leaves 3% of the rainfall falling in the catchment.

- (iv) 20 hectares of dense mid slope and upper slope Eucalypt plantations

20 ha (7.4 mm/d = 2701 mm/yr)

$2.701 \times 20 = 540,200 \text{ m}^3/\text{yr}$

$464,676 - 540,200 = -75,524 \text{ m}^3/\text{yr}$ (of soil stored water) which begins to draw upon stored soil water.

APPENDIX 2

Establishment and management of perennials – in general:

Species

Very dependent on soil type, degree of salinity and/or waterlogging. Cost of seed varies between species as well as between cultivars.

Site preparation and weed control

In most cases, the area to be sown should be fenced out. *Weed control must be excellent.* Perennials are not vigorous seedlings and cannot withstand any competition at all in the first season. Ideally, spraytopping with Round-up, Sprayseed etc. (1–2 L/ha) or heavy grazing, to reduce weed seed set should occur the year prior to perennial grass establishment (preferably two years if affordable). A hot autumn burn can also assist in killing grass seeds. Weeds can also be controlled through cropping, however on some soil types this would not be a viable option.

A fine, firm seed bed needs to be prepared if cultivating. In areas where previously there has been dense stands of barley grass or ryegrass, cultivation is advisable as germination of these seeds are stimulated. Sowing depth should be no greater than 1.5 cm.

The method of sowing will depend on implements available. Depending on past experience, farmers may either chose to sow seeds through small seeds box on combines or run seed mixed with fertiliser through the fertiliser box. Either technique is successful – basically 'just do what you normally do' when sowing pastures.

Implements such as sod-seeders or machines fitted with Baker boots, coulter tynes or lucerne points appear to assist in getting a better establishment, however they are not essential. They are also an added cost so if there is a failed establishment, losses are greater.

As with anything that is new, it is difficult to get 'everything right' first time round, particularly with perennials as they establish slowly often taking two–three years to reach their full potential. However, their long term benefits of *higher water use, decreased erosion and weed problems and the provision of good nutritional green feed out of season* are worth the care they require initially.

Seed treatments and rates

Normally perennial grasses are sown as a mixture with annual legumes such as balansa clover, subterranean clover or serradella or with strawberry clover (perennial). All legumes should be treated with LeMat insecticide (620 mL/2.5 L of water for 100 kg seed, Cost = 25¢/kg seed) 24 hours prior to inoculating and lime pelleting. Please see the following for inoculums and techniques to be used:

- (i) Farmnote 6/87 – 'Techniques for inoculation and lime pelleting.'
- (ii) Farmnote 33/91 – 'LeMat and legume inoculation.'
- (iii) Bayer Australia Pty Ltd technical manual – 'Directions for mite-proofing seed with Le-Mat.'

The treatment of seed with LeMat can be omitted if costs need to be cut. Insecticide treatment can be done post-emergent, however red-legged earth mite can cause damage to seedlings before emergence. Treatment with LeMat provides up to three to six weeks protection for the seed and emerging seedling even under heavy infestations of earth mites.

Sowing rates vary with species. The list below indicates the rates of some of the more commonly used perennials. In most cases, the higher the sowing rate, the better the establishment, but also higher the cost! If sowing mixtures lower seeding rates can be used.

A mixture for example:

Species	kg/ha	Species	kg/ha
Puccinellia	3–5	Puccinellia	3
Tall wheat grass	6–8	Tall wheat grass	3
Fescue	5–8	Phalaris	3
Phalaris	3–6	Fescue	4
Rhodes grass	3–6	Balansa clover	1
Veldt grass	3–6		
Cocksfoot	3–6		
Perennial ryegrass	6–8		
Lucerne	4–8		
Strawberry clover	1–4		

Time of sowing

The majority of perennials should be sown as early as possible after the autumn break to give the plants sufficient growing time to produce a large root system to enable it to survive its first summer. Some species such as Rhodes grass, kikuyu and Consol lovegrass need to be sown in spring as the seeds require warmer soil temperatures to germinate.

Post-sowing requirements

Insect control with either Rogor (85 mL/ha) or LeMat (50 mL/ha) should be done seven to ten days after sowing if seeds have not been treated previously. Thereafter – as required.

Chemical weed control is difficult in a mixed legume/grass pasture, hence the need for excellent weed control initially. The only option is hard, fast grazing. In pure stands of lucerne, grass seeds can be controlled by grass selective herbicides and broadleaf weeds to a certain extent by spraytopping with Sprayseed or Gramoxone. Sprayseed etc., will burn the lucerne however it will re-shoot and 'grow out of the damage. Similarly with pure phalaris stands except broadleaf weeds are controlled by broadleaf selectives and other weeds by spraytopping.

Fertiliser

This will depend on soil type and paddock history but usually perennials are sown with 100 kg/ha superphosphate plus trace elements if trace elements have not been applied in the last ten years. Once established, perennial pasture will respond to annual topdressings of superphosphate (50–100 kg/ha), nitrogen (50 kg/ha) and in many cases potash (50–100 kg/ha).

Grazing management

Perennial pastures should preferably be rotationally grazed as set stocking will destroy them over time. However, if only small areas are sown to perennials, these can be best utilised by 'opportunistic grazing' i.e. hard, fast grazing with large numbers of stock when feed is available. The paddock should then be rested for at least 4 to 6 weeks before grazing again.

In the year of establishment, perennials should only be graze to control weeds and allowed to run up to head and set seed. Thereafter, it can be grazed as often as necessary without over-grazing i.e.; allowing the stock to eat into the crown of the plant. If overgrazed, pasture will thin out and/or die.

Perennial pastures, in particular phalaris, tall wheat grass and veldt grass need to be managed well, otherwise they will become rank, unpalatable and unproductive.

Deficiencies of the system

The major deficiencies with perennial pastures are:

- (i) poor establishment of the legume component in saline areas;
- (ii) sowing, spraying or cultivation are often difficult due to the landscape or waterlogged soils where perennials are being targeted;

(iii) large enough areas sown to perennials to fully implement a rotational grazing system.

Establishment costs

Seed costs (from Mt Barker Seedworks – (098) 51 1306 in 1990):

		\$/kilogram of seed
Puccinellia		5.60
Tall wheat grass		3.00
Phalaris	- Sirolan	6.00
	- Siroso	5.40
Fescue	- AU Triumph	5.20
	- Demeter	3.20
Rhodes grass	- Pioneer	12.00
Veldt grass	- Mission	6.00
Strawberry clover		9.50
Lucerne	- Hunterfield	4.40
	Sheffield	4.50
	Siriver	4.50
	Trifecta	5.20
Annuals:		
Balansa		2.50
Serradella	- Madeira	5.00 certified
		4.70 uncertified

Cost of establishment will depend on seed used and at what sowing rate, whether fencing is required and what sowing rates are used, conventional or chemical.

An estimate would be:

		\$/hectare
fertiliser	-	8.00
sprays	- 1 knockdown	
	1 insecticide (Rogor)	8.00
Fuel/oil/maintenance of machinery		8.00
Seed mixture	- puccinellia (3 kg/ha)	
	tall wheat grass (3)	
	balansa (1)	24.00
TOTAL		\$48.00/ha

Benefits of perennials:

The major benefits of perennials are:

- (i) production off marginal soil types;
- (ii) provision of green feed outside the normal annual growing season;
- (iii) once established, feed for the autumn/winter period reducing hand-feeding costs;
- (iv) reduced weed problems;
- (v) high water users;
- (vi) alternative grass species for annual ryegrass toxicity areas.

Growth habit:

For the growing periods of those species mentioned, refer to the table titled 'A Guide to Perennial Pasture Species Selection.' The majority of perennials are also very responsive to rainfall over summer.

Productivity:

Some production figures and initial assessment of perennials from farmers already using them.

- (i) In the North Stirlings, veldt grass/serradella on deep sandy dunes has raised stocking rates from 1 DSE/ha for 1 month's grazing in the year to 3 DSE/ha for two month's grazing.
- (ii) Lucerne as a hay crop has the potential to yield 2–3.5 tonne/ha.
- (iii) Phalaris, fescue and tall wheat grass mix sown over a saline water table at 50 cm 'paid for itself' within the first year of establishment.
- (iv) In many instances, lucerne and/or mixed perennial grass stands have reduced watertable levels.

Preliminary research in the Eastern States indicates that:

- (v) The existence of a perennial pasture is equivalent to topdressing 60 to 90 kg/ha of lime per year.
- (vi) Water use by phalaris has been measured to be 20–25 mm/month over June–September and 35 to 40 mm/month over October.

Recommendations for the soil types in the Byenup Hill catchment

Salty gullies, salt seeps and flooded gum gullies

Suitability: revegetation / permanent perennial pasture.

Species: dependent on the severity of the salt.

- Severe salt – saltbush (S. Vlahos's article for recommendations?)
puccinellia
tall wheat grass
saltwater couch
fescue
Rhodes grass (spring sown)
Paspalum dilatatum (spring sown)
- Mild salt – phalaris

Balansa clover and strawberry clover are good companion legumes for the above grasses. These legumes will not establish in very saline areas.

Gravelly ridges

Suitability: revegetation / perennial pasture / cropping (?).

Species:

Phalaris, fescue, perennial ryegrass, cocksfoot either sown as a mixture with subterranean clover or selected species as a mix with subterranean clover e.g. phalaris/sub. clover or phalaris/fescue/cocksfoot/sub. clover.

Granite hills

Suitability: revegetation/perennial pasture/cropping.

Species:

If the rocky areas are too widespread for successful cropping, the alternatives apart from planting trees would be lucerne or veldt grass/serradella mix for the deep sands and for the shallower ones lucerne; cocksfoot/serradella or sub-clover or possibly tall wheat grass/sub. clover, however research with tall wheat grass on sands is only just starting. Rhodes grass sown in spring or 'Puna' chicory may also be worth a try.

Mallet hills

Suitability: Revegetation or leave as trees.

Marri sands (gentle, moderate or steep slopes)

Suitability: Higher areas may be suited to cropping/permanent perennial pasture.

Species:

In all three instances, a veldt grass/serradella mix or veldt grass/rose clover mix would be most appropriate. Less commonly known plants such as Evening Primrose (biennial – however regenerates extremely well from seed), 'Pioneer' Rhodes grass and 'Puna' chicory would also be worth experimenting with. Another alternative would be tagasaste as a pure stand or inter-rowed with the above species. Initial research also indicates tall wheat grass may be persistent on such sands.

If wind erosion is a problem, the perennials could be sown using a cover crop such as cereal rye, or oats/barley sown at a low seeding rate (15–20 kg/ha). This cover crop would then need to be grazed off by mid to late August to ensure the perennials are competing with it for moisture or sunlight.

If waterlogging is a problem on this soil type, phalaris sown with either sub. clover, balansa clover or trikala clover may be more suitable.

Dykes

Suitability: Revegetation/permanent perennial pasture.

Species:

If salting is occurring downslope a mix of puccinellia, tall wheat grass, fescue, balansa and strawberry clover would be recommended.

Upslope – phalaris, fescue mixed with either balansa, sub. clover or medic.

There has been reports of lucerne doing well on these clays as long as the clay is uniform and no hard-pan is present.

Quartz seams

Suitability: Replant to trees.

Prior stream sands

Suitability: Revegetation/permanent perennial pasture.

Species:

Tall wheat grass, veldt grass sown with serradella would be the most appropriate recommendation. Again, Evening Primrose or 'Puna' chicory may also be worth considering.

APPENDIX 3

Alley Farming Establishment Notes

'Alley farming' means using a planned, managed combination of woody perennials (shrubs and/or trees) in line, with cropping or grazing in-between.

The two main forms of alley farming being developed in Western Australia are:

1. **Sand plain alley farming.** Commonly, the 'hedges' are composed of fodder shrubs and sometimes other small to medium sized trees. Pastures or crops (where suitable) are managed in the 'alley'. Perennial pastures are beginning to play more of a role in this system in the medium to high rainfall areas.
2. **Salinity/watertable control.** A common example is on valley floors in the wheatbelt that are affected by shallow and saline shrubs. The 'hedges', or tree lines, are less likely to contain fodder shrubs. However, there is considerable interest in salt tolerant Acacias for fodder and legume values.

These notes only cover alley farming for salinity and watertable control.

Design factors in salinity/watertable control alley farming

Site selection

Sites that are relatively flat and moderately affected by salinity are suitable. Areas with very active discharge, exposed clay soils, bare salt scald, or water ponding, are not very suitable.

Alley farming in this situation will be more effective where:

- Soils have a sandy surface.
- Soils are porous or have reasonably high water conductivity at depth.
- Suitable tree species are available and survival is good.
- Tree lines are quite close together.
- Watertable is rising slowly, is still more than 1 metre down, and is only moderately saline (less than 2000 mS/m).
- Soil saline is moderate. That is, the soil extract salt level (EC1:5) is less than 400 mS/m.
- Surface water ponding can be prevented.

Spacing of trees

For the most efficient effect on watertable (but not necessarily the best for management), trees should be planted on an even grid spacing. That is, trees have the same spacing within rows as between rows.

In practice, single rows of trees, with trees 5 m apart within the rows, could be spaced from 10 m apart to about 40 m or 50 m apart. The wider spacing will be slower to show an over-all response. Narrower spacings are recommended on heavier soils and where the watertable is shallower and more saline. Wider spacings are most suited to sites with lighter soils, and deeper, less saline watertables.

Spacing between rows should depend on soil type, depth to watertable, salinity of the watertable, and width of machinery that will be used on the site.

Most plantings on valley floors for watertable/salinity control have single rows less than 30 m apart.

Two or more rows planted in belts, with an alley in between, could also be used. However, planting two rows rather than one will not allow the alley to be twice as wide. The major limitation on spacing is movement of water through soil adjacent to the trees. In most heavier soils, water will not move as rapidly sideways as it will vertically. Therefore, trees may lower the groundwater rapidly underneath the trees, but slowly at a distance from the trees. Single lines of trees in rows up to 25 m apart should be adequate; double rows with alleys wider than 25 m may be worth trying.

Tree species

Local experience with tree species is worth investigating. Variability in disease and insect/pest problems may change the choice of species within relatively small distances. However, there is a fairly restricted range of species that have been tried and found to be particularly useful.

The unusual reason for choosing a tree in valley floor alley farming are that it has salt and waterlogging tolerance, is easy and reliable to establish, grows rapidly in the early years, has demonstrated tolerance to insect attack, and is unlikely to become a weed. Species that have met the criteria included:

Species	Common name/note
<i>Eucalyptus occidentalis</i>	Flat Topped yate or swamp Yate. Wide natural distribution, good salt and waterlogging tolerance. Rapid growth. Tested in many areas. Recovers well from insect attack.
<i>Eucalyptus spathulata</i>	Swamp Mallet. Fairly fast growth. Dense crown of fine leaves. Has a reputation for blowing over on heavy soils when roots are shallow.
<i>Eucalyptus camaldulensis</i>	River Red Gum. There are many forms, including cloned material. Choose one of the salt tolerant types with good form. Fast growth, fairly open crown on some forms. Liable to leaf pests in some areas, and may be to leaf pathogens.
<i>Eucalyptus sargentii</i>	Salt River Mallet. Small tree, wide branching. Good salt tolerance. Moderate growth rate. Sometimes liable to leaf eating insects.
<i>Eucalyptus loxophleba</i>	York Gum. Moderate salt and waterlogging. Fast growth. Has not been used as much as the above species.
<i>Casuarina obesa</i>	Salt Sheoak or Swamp Sheoak. Very good salt and waterlogging tolerance. Moderate growth rate. Foliage highly palatable to livestock, but bark usually safe. Resistant to most insect problems (locust are a partial problem). Could be planted at greater density than Eucalypts.
<i>Acacia saligna</i>	Golden Wreath Wattle. Fast growing. Most types have good salt tolerance, some types also have good waterlogging tolerance. Is a small bushy tree. Highly palatable to livestock, and is a worthwhile supplementary fodder. A legume.

There are many species with salt tolerance that are relatively untested in farming conditions. There may be an opportunity to test these new species in combination with the species above. If the species are also expected to be directly productive, more information will be needed. For instance, the expected product, tree growth characteristics, management for production and so-on.

Site preparation and planting

The normal recommendations for salt affected or waterlogged sites apply:

- Earth works to remove/prevent surface water and waterlogging.
- Fencing to exclude livestock and native graziers.
- Rip all lines to about 60 cm (depending on hardpans etc.).
- Mound all areas affected by salt or waterlogging.
- Spray a residual herbicide over the mounds and leave for about 4 weeks before planting.
- Plant by hand for preference. This usually gives better planting depth, compaction around the roots, and less root damage.

APPENDIX 4

Saltland Agronomy

Introduction

The purpose of this section is to discuss possible agronomic approaches to the management of saline Land management Units in the Byenup Hill Catchment. The causes of land salinisation are discussed in Section 12.

The Land Management Units

Two land management units (LMU) were identified in the Byenup catchments; (1) salty gullies and (2) salt seeps. I feel that the salty gully LMU would be better divided into salty gullies and salty valley floors. A summary of the potential land uses for each LMU are described in Table 1.

Table 1. Summary of management options for LMUs with saline and/or waterlogging degradation in Byenup Hill Catchment, and lower catchments of the Carlecatup

LMU	Possible land uses
(1) Salt Seeps	- Dry out seep by strategic tree planting
(2) Salty Gullies	- Establish a covering of salt tolerant pasture.
(3) Saline Valley Floor	- Fence and revegetate
	- Fence and establish grazing pastures
	- Agroforestry/Alley farming to lower water tables
	- Establish pastures of
	- Perennial grass pastures
	- Shrubs <i>Acacia saligna</i>

Management Options

LMU 1 – Salt seeps

The salt seeps tend to be small areas in the mid to lower slopes. The two options available for this unit are to reclaim the saltland by planting trees above the seep to use the water before it gets to the surface and/or revegetate with salt tolerant pastures and forages.

Consult your Land Care Technician or the department of agriculture for site specific recommendations to dry out the seep. Refer to Richard George's article 'Reclaiming sandplain Seeps by Planting Trees' (WA Journal of Agriculture; Vol 132, pp. 18–23).

Depending on the severity of the salinity the seep itself can be revegetated with salt and waterlogging tolerant pastures and forages. Refer to Farmnote 32/86 for plant recommendations.

LMU 2 – Salty gullies

This LMU includes the drainage line and immediate surrounding land. The area involved is usually small. Subject to periodic flooding and generally supports remnant flooded gum (*Eucalyptus rudis*). These areas may be revegetated with trees or pastures.

The gullies need to be fenced to encourage revegetation and minimise water erosion. Because of their long narrow shape these areas are best left as timbered drainage lines. They can be planted to trees, but, if, fenced and cultivated with some weed control flooded gums will self seed very easily. The high water use of trees on this LMU will also help reduce the spread of salinity. *Acacia saligna* can be direct seeded into the areas to provide shelter and increase water use and provides forage.

If grazing is a preferred land use perennials grasses and shrubs may be established. For the less saline soil, the mildly salt and water logging tolerant grasses and legume should be established. The more severe areas, are better suited to puccinellia and saltbush.

LMU 3 – Salty valley floors

Lower in the Byenup catchment the valley floors are broader and subject to **waterlogging** and **salinity**. It is important to differentiate between the two as barley grass is an indicator of waterlogging and salinity. In either case removing the surface waterlogging is necessary. Refer to your local Land Care Technician or the Department of Agriculture for specific site drainage recommendations (see Objective 2).

Generally the valley floors in this catchment are not very saline and this LMU offers a wide range of options including:

a) Perennial grass pastures

Generally the saline valley floor soils suffer more from water logging the salinity. Removing the surface water will increase the range of pastures suitable for this LMU. (Refer to C. Saunders' article for recommended pastures.)

b) Saltbush

Small areas of bare soil with salt crust were observed but these generally occupy only on a small proportion of the total LMU. Saltbush and puccinellia are more appropriate for these more saline areas.

c) Agroforestry or alley farming

The high water tables on the valley floors can be lowered using widely spaced tree lines. The areas between the trees can be cropped, cut for hay or established to perennial pasture (refer to C. Saunders' article for pasture recommendations). In a trial established in 1981 at Boundain, 20 km east of Narrogin, water tables were lowered 1.0 to 1.5 m by rows of trees at spacings of 12.5 and 25 m after 5 years (Farmnote 46/88). Refer to David Bicknel and Richard Moore for recommendations on trees.

Suggested field trials

I suggest a number of field trials be carried out by the LCD to determine the most appropriate pasture species for each soil type and conditions. Comparisons between the perennials/annuals waterlogging tolerant species and the salt tolerant saltbushes need to be made to determine the most productive. The suggested species for this trial are:

Salt tolerant species

River saltbush	<i>Atriplex amnicola</i>
Wavy leaf saltbush	<i>Atriplex undulata</i>
Quailbrush	<i>Atriplex lentiformis</i>
Grey saltbush (prostrate variety)	<i>Atriplex cinerea</i>
Puccinellia	<i>Puccinellia ciliata</i>
Samphire	<i>Halosarcia</i> spp.

Waterlogging Tolerant (refer to C. Saunders' article)

Balansa Clover
Phalaris
Fog grass
Tall wheat grass
Fescue
Rhodes grass
Strawberry clover

Prescription for establishment of saltbush in the Byenup Hill catchment

1) Off and on site water control measure

Waterlogging is a major factor limiting production on the saline soils and must be reduced to improve establishment and productivity. This will involve off site earth works to reduce ground water recharge and surface flow into the site, and increasing discharge from the site.

2) Plant selection

Selection of the species suitable for each site will depend on the soil salinity, degree of waterlogging, and soil texture. The presence of barley grass can be used to indicate waterlogging and salinity. For this catchment, areas with a covering of barley grass are generally a result of waterlogging rather than salinity. Patchy barley grass and bare soil indicate salinity.

Suggested pasture species for each saltland type in the Byenup Hill catchment.

	Vegetative cover	
Soil texture	Barley grass (Waterlogging?)	Patchy barley grass to bare soil (Salinity present)
Sandy (10 cm)	(1) Balansa Phalaris Fog Grass Tall Wheat Grass Fescue Strawberry clover Rhodes grass	<i>Atriplex amnicola</i> <i>Atriplex undulata</i> <i>Atriplex cinerea</i> <i>Atriplex lentiformis</i> Puccinellia Tall wheat grass
Clay	(1) Balansa Phalaris Fescue Tall wheat grass Strawberry clover Fog Grass	Samphire Puccinellia tall wheat grass Saltbush (Note: saltbush generally has poor growth on heavy soils.)

(1) Refer to C Saunders' article for establishment/management recommendations.

3. Site preparation

- a) Determine species limits (see 2 above). Establishment costs can be reduced by only sowing species in the appropriate soil conditions.
- b) Sow grasses in May/June (Ref. C. Saunders). If grasses are not being established then the preparation of the site for saltbush should involve weed control, cultivation and deep ripping.
- c) Weed control
 - Heavy grazing, burning.
 - Use knockdown herbicides only as many of the residuals (i.e. Simazine) have been reported to affect saltbush.

Where a mixture of grasses and saltbush are being established, grasses may compete with the establishing saltbush. However the mounding operation will bury most of the Puccinellia and Tall Wheat Grasses established in May/June. Where competition does occur the grasses can be controlled with the grass specific herbicides Fusilade® or Sertin®. Only the grass on the mound needs to be controlled.

d) Cultivation

Where possible cultivation is recommended to improve soil tilth. Cultivation increases salt leaching from the soil and results in a better seed bed improving establishment and growth.

e) Deep ripping

Deep ripping improves the growth of saltbushes. Most seeders and mounders have a deep ripper. Mounding over a rip line is recommended where machinery does not have a ripper.

4. Establishment – direct seeding or nursery raised seedlings

Choice of establishment method depends on the soil conditions.

Soil is sand to loam deeper than 10 cm	Niche seeding
Soil is sand to loam less than 10 cm	Seedlings or Niche seeding if surface of soil does not slake/disperse and bury the seed.
Soil is a clay	Seedlings, as establishment by niche seeding is unreliable.

Nursery raised seedlings and niche seedlings are the two techniques used to establish saltbush. Nursery raised seedlings usually have a 90% success rate. However, their cost can be prohibitive. This cost can be reduced by raising your own seedlings. Research is being conducted into using bare root seedlings which are grown and planted without soil around the roots. Unfortunately establishment to date has been very variable, especially on saltier soils.

Niche seeding is a method specifically developed for establishing shrubs on saline soils. The principal of the technique is to create a favourable seed bed around the seed to allow the seedling to establish. Once the seedling has established it can tolerate high soil salinity. The niche seeder uses opposed discs to raise a mound into which a shallow 'V' shaped 'niche' is pressed. Seed is deposited at 1 to 3 m spacing into the valley of the depression and covered with a mulch of vermiculite. Generally a ripper is placed in front of the opposed discs to break up the compacted soil.

The raised seed bed in the mound reduces water logging around the establishing seedling and promotes leaching of the salt. The 'V' shaped valley shelters the seed and harvests water to that soil at the bottom of the valley which is leached of salt. The vermiculite mulch retains moisture around the seed placement and reduces the accumulation of salt around the seed by capillary action. The deep ripping aids salt leaching and root penetration.

5. Seedling spacing and seeding rate

a) Seedling

Recommended plant spacing for the preferred saltbush species.

Species	Spacing (m)		Plants/ha
	Row	Plant	
River saltbush (<i>A. amnicola</i>)	3	3	1100
Wavy leaf saltbush (<i>A. undulata</i>)	3	2	2200
Grey saltbush (<i>A. cinerea</i>)*	4	4	625

* Long term grazing tolerance and productivity of this species is not known.

Research has shown that forage production per plant decreases as plant spacing decreases. On a area basis, the closest spacing at which saltbush forage production no longer increases significantly depends on the species. For the smaller species such as *A. undulata* more plants per/ha are required to achieve the same production as the larger *A. amnicola*. For this reason *A. amnicola* is the preferred species when using seedling. Grey saltbush is a

larger plant requiring less per ha for the same production. However, the grazing value and persistence of this species has not been determined.

b) Seeding rate

To maximise establishment a high seeding rate is essential. The current recommendation is to sow saltbush in rows 3 m apart with 1.6 m spacing between placements. This results in approximately 2000 placements per ha. Each placement should contain 50 germinable seeds to ensure at least one seedling establishes. The seeding rate (kg/ha) will depend on the quality of the seed to be used and the number of placements per ha. (See Farmnote 81/91, 'Calculating saltbush seeding rates'.)

6. Seeding and planting time

Waterlogging, low temperatures and rainfall are the factors which determine the time to seed or plant seedlings. **Early spring** (September to early October) is the most appropriate time for this region when the threat of waterlogging has receded, temperatures are increasing and follow-up rains are still expected.

7. Insect control

Insects, especially RLEM (reg legged earth mite) can kill the small emerging saltbush seedlings. The saltbush should be inspected weekly after seeding and if RLEM are seen the saltbush should be treated. Systemic chemicals may not give appropriate insect control as the seedlings are usually too small to tolerate insect attack. Suggested treatments are:

- Chlorpyrifos (Lorsban®) 140 mL/ha (\$5/ha)
- Omethoate (LeMat®) 150 mL/ha (\$7/ha)

Check and retreat as necessary.

Grazing management

a) Graze 18 months after sowing

Saltbush is best left to establish for 18 months before grazing. However, if there has been good establishment and the plants are growing vigorously (over 0.5 m tall), a light grazing is unlikely to be detrimental. Once established saltbush will tolerate heavy grazing annually.

Grazing intensity	Degree of defoliation
Light	25% of leaf material
Moderate	50% of leaf material eaten
Heavy	Most leaf material eaten
Severe	Twigs are being eaten

b) Graze in conjunction with other forage and remove sheep when most of the leaf has been eaten

The nutritional value of saltbush (protein, digestibility) indicates it is a maintenance feed only. Saltbush intake is limited by the high level of salt and is best grazed with other feed such as stubbles, dry pasture, hay and grains (oats/barley). Weaners, pregnant and lactating ewes will require supplementary feed with saltbush.

In the past saltbush was grazed until stems up to pencil thickness were eaten. Recent research indicates the nutritional value of the stem material is inadequate even for maintenance. Stock should be removed when most of the leaf is gone or the stems are being eaten.

c) Graze during summer/autumn

Saltbush is generally grazed in later summer/autumn when annual feed is in short supply and of low quality.

d) Include experienced sheep

Sheep new to saltbush take some time to learn to eat it.

e) Provide plenty of good quality water.

Recommended maximum water salinity for classes of sheep grazing saltland (mS/m).

Feed	Adult dry sheep	Weaners, pregnant and lactating ewes
Saltbush and other feed	100	500
Saltbush only	500	500 (Not recommended)

Costs and benefits of saltbush pastures

The tables following indicate the costs and returns from establishing salt tolerant grasses and saltbush pastures.

The costing assumes all items are necessary. Labour costs are not included except where two people are required to plant seedlings. Actual establishment costs will vary according to the specific situation.

Although fencing, water supply and drainage contribute up to half the total cost, some of the establishment cost can be reduced. Collecting your own seed may reduce direct seeding costs by 20%. Seedling costs can be halved by growing your own.

Establishment costs of establishing saltland with salt-tolerant grasses and shrubs by direct seeding and seedlings.

Item	Approximate costs (\$/ha)
------	------------------------------

Direct seeding

Weed control(chemical Roundup® + application)	15
Seed bed preparation, scarifying (fuel and tractor cost)	8
Weed control (chemical Roundup® + application)	15
Grass seed (2 kg puccinellia/ha, 5 kg tall wheat gras/ha)	20
Sow grass (fuel + tractor costs)	6
Saltbush seed (1.5 kg/ha, Wavy and River)	30
Niche seeder (hire)	5
Sow saltbush (fuel + tractor costs)	6
Vermiculite (2 x 100 L bags)	26
Insect control (2 applications of LeMat)	10
Total direct seeding cost	151

Used seedlings

Weed control	15
Scarifying (fuel + tractor cost)	8
Weed control (chemical Roundup® + application)	15
Grass seed	30
Sow grass (fuel + tractor costs)	6
Insect control (2 applications of LeMat)	10
Hire moulder/ripper/planter (5 ha/day @ \$60/day)	12
Seedlings (1000/ha @ 25 cents)	250
Planting (fuel + tractor costs)	5
Labour (takes 2 to plant seedling, 6000 seedlings/day, wages \$90/day)	18
Total seedling costs	369

Fixed costs	
Fencing (\$1400/km material only) (fencing ratio 71 m fence/ha)	100
Water supply (\$1200/50 ha) (Trough, valve, cover, 500 m 25 mm polypipe)	24
Surface drains (\$400/km, 25 m/ha)	16
Total infrastructure costs	140
Total direct seeding	291
Total used seedlings	509

Costs do not include labour.

Forage production and utilisation

Assumptions

1. Forage produced is used during the summer/autumn feed gap.
2. 1.0 t saltland forage is equivalent to 0.8 t oats.
3. Hand feeding has a total cost of \$110/t (assumes buying in and storage of oats)
4. Total forage (saltbush and other grasses) produced is 1.5 t dry matter/ha per annum.
5. Grazing starts in year 2 and is maintained for 10 years.
6. All establishment and infrastructure costs incurred in year 1.
7. Saltland currently has not got any production.

Other benefits not accounted for include:

1. Increased water use (saltbush uses about 400 mm/yr).
2. Improved annual pasture establishment and growth by deferred grazing.
3. Nature conservation.
4. Stock shelter.



Direct-seeded eucalypts and understorey (two year old) at Balgarup.

APPENDIX 5

Timber production from wide-spaced agroforests

Summary

The paper outlines why growing trees at wide-spacings is an important option for farmers. In particular it points to the fact that wide-spacing enables timber to be a realistic possibility in farming areas which receive as little as 450 mm of rain per year. It also highlights innovative developments on farms to adapt wide-spaced agroforestry to suit farmer's needs.

One of the layouts favoured by farmers is strips of wide-spaced trees because it fits well with conventional farming practices such as cropping and grazing. The techniques developed for managing wide-spaced trees, mainly pruning, are applicable to all layouts of wide-spaced trees. Results of pruning trials indicate that eucalypts take substantially less time to prune than pine.

Volume of timber from an agroforest of pine is about 80% of that from conventional plantation. Growth rates of fast grown eucalypts at wide-spacing during the first 8 years indicate that they will reach sawlog size by 20 years – sooner in the case of *E. globulus*.

Introduction

The conventional view of wide-spaced agroforestry is a parkland of pine trees. However, as more areas are established on farms, the picture is changing. Imaginative layouts and different species are some of the adaptations being made to mould the concept into a form which suits farmers.

The combination of wide-spaced pine trees for sawlogs and pasture for grazing has been studied in Western Australia since 1973. The finding that this type of agroforestry can be more productive than a pure grazing enterprise has been widely reported [Anderson *et al.* 1987]. Economic studies support these findings [Malajczuk *et al.* 1984].

Although much of the research has concentrated on wide-spaced pine, the findings are applicable to different layouts and species. For example, the principle that wide-spaced trees must be pruned to produce saleable timber is relevant no matter how the trees are arranged across the paddock.

This paper discusses wide-spaced agroforests in the context of recent adaptations being made on farms. Four questions are addressed:

1. Why consider wide-spaced agroforests?
2. What layout options are there?
3. What are the main tasks in managing the trees?
4. How much timber is produced?

Why consider wide-spaced agroforests?

Growing trees at wide spacing greatly extends the rainfall zone over which trees for sawlog timber can be considered a realistic possibility. The lower limit of rainfall for conventional plantations is about 700 mm in northern areas and 600 mm in the south [CALM, 1987a]. In areas which receive less rainfall than this there is a high risk that trees will die from lack of water. Spacing the trees out avoids this problem and enables trees for sawlogs to be grown in areas with as little as 500 mm rainfall per year in northern areas and 450 mm in southern areas. This means that a much greater area of farming land in the South West can produce timber as a part of using trees in farming. It is in lower rainfall areas that salinity and wind erosion are serious problems and trees are urgently needed.

The ability to grow trees at wide-spacing opens up many new options for arranging trees. Flexibility in tree layout means that trees can be arranged in ways which integrate well with conventional farming practice. For example, trees laid out in narrow strips can be effective at preventing wind erosion and at providing shelter as well as enabling the farmer to crop or graze the land. However, because the bulk of the trees are "edge trees" they are essentially wide-spaced. Therefore if the farmer also wants the trees to produce timber he must prune them.

Agroforests are well suited to producing high quality sawlogs. In wide-spaced stands growth of timber is concentrated on a few well formed trees – the poorly formed ones having been culled out in the early years. Thus how to sell thinnings, a problem faced by so many private growers of agroforest. High quality sawlogs are easy to sell.

What layout options are there with wide-spaced agroforests?

There are two main types; strips and windbreaks.

1. Strips

Strips of trees can be laid out in many ways; the number of rows per strip and the distance between rows can be varied to suit the needs of the farmer.

In medium rainfall areas [500 to 700 mm rainfall per year] the need to combat salinity is likely to be the primary reason for tree planting. Strips of several rows of trees 30 to 80 metres apart on the contour is a practical arrangement with this objective in mind. It enables the farmer to continue to crop his land and also benefits his pasture and livestock by providing shelter. In addition the farmer can manage the strips as wide-spaced stands. Thus the growth of timber is concentrated on the best trees and so he can expect to produce sawlogs in about 30 years.

Farmers in high rainfall areas [> 700 mm rainfall per year] are likely to establish wide-spaced agroforests to increase productivity. They consider that the combination of wide-spaced trees and pasture is a more productive use of land. The benefits trees provide in terms of shelter is part of the reason for greater productivity. A typical layout is double rows 25 metres apart.

2. Windbreaks

Windbreaks differ from strips in that their primary function is to reduce wind speed. In Western Australia this is usually to prevent wind erosion and to provide shelter. These objectives influence the structure and management of the belt of trees. For example, windbreaks are usually fenced to stop livestock from browsing and low species are planted to provide effective low shelter. A spacing of 200 mm is commonly used on Western Australia's south coast to adequately protect the whole landscape.

Windbreaks can also produce saleable timber. A survey of pine windbreaks in the Esperance area found that from 46 to 146 m³ of sawlogs per kilometre can be produced in 30 years [Moore, 1987].

Most windbreaks consist of two or three rows. Thus the majority of trees are "edge-trees". Therefore they need to be managed as wide-spaced trees if the intention is to produce saleable sawlogs.

What are the main tasks in managing trees for timber?

The bulk of work in tending the trees is carried out from about three to 12 years of age. During this time the best 75 to 200 trees per hectare are chosen and the rest are culled. The retained trees are pruned to a height of six to 10 metres.

Pruning is the most costly task, accounting for about 80 per cent of all costs. However, pruning is essential to produce saleable timber and to let in light for the pasture.

Less pruning is required with eucalypts than with pine. Pine trees may require as many as six or seven prunings whereas fast growing species of eucalypts can be pruned to a similar height in two or three prunings. Table 1 below presents data on time to prune pine and eucalypts.

Table 1. Total time to prune wide-spaced *P. radiata* and *E. globulus* to 7.5 m

Species	Time to prune (min/tree)
<i>P. radiata</i>	17
<i>E. globulus</i>	8

From 12 years until the trees are harvested at about 30 years, the trees require no further tending. Table 2 lists the main tasks involved in setting up and managing an agroforestry area with pine; their timing and approximate cost.

Table 2. Task, costs and returns for the tree component of an agroforest with 100 pine trees per hectare. The cost of pruning is less for eucalypts

Age (yrs)	Operation	Costs (\$/ha)	Returns (\$/ha)
0	control weeds	20	
	seedlings (670/ha)	70	
	plant seedlings	36	
	fertiliser seedlings	32	
3 or 4	cull malformed trees (leave 300 sph)	25	
	prune	75	
5 to 7	cull to final crop (100 sph)	20	
	prune (with "Squirrel")	100	
8	prune	100	
10	prune	100	
12	prune	100	
18	thin 50 sph for sawlogs (optional)		
30	harvest remaining trees		\$3,500 to \$10,000

Further details are provided in the booklet entitled, "Agroforestry – an alternative approach to farming" [CALM 1987b]. It is important that attention to detail be given.

Table 3 below presents the total costs and the likely returns per pine tree. It is a simplified but worthwhile comparison to make. The actual costs for any given situation depend on a number of factors including, soils, rainfall and management methods.

Table 3. Approximate total costs and returns per tree (*P. radiata*)

Total costs (\$/tree)	Total returns (\$/tree)
\$10 to \$12	\$75 to \$150

How much timber is produced?

The volume of sawlogs obtained from a pine after 30 years is about 80% of the timber produced from a pine plantation [depending on the number of trees per hectare]. Table 4 below presents data from agroforestry trials near Mundaring.

Table 4. Estimated volume of timber at 30 years for an of 100 pine trees per hectare compared with the volume from a conventional plantation. Data from experimental sites at Flynn's and Wellbucket, Mundaring, Western Australia

	Agroforest (sawlogs)	Plantation (chipwood & sawlogs)
Volume of timber (m ³ /ha)	190	240

A substantial proportion of the timber from a pine plantation is small logs, used for posts and chipboard. This material is less valuable than sawlogs. Therefore the value of pine timber produced from an agroforestry stand is more than 80% of that produced from a plantation.

Preliminary findings from studies with wide-spaced eucalypts indicate that fast growing species will produce sawlogs in about 30 years. Table 5 presents data fro several species of eucalypt growing at wide-spacing near Busselton.

Table 5. Growth data for 7.5 year old eucalypts at 150 sph at an experimental site near Busselton

Species	DBHOB (cm)	DBHOB Incr (cm/yr)	Height (m)
<i>E. globulus</i>	29.4	4.9	15.5
<i>E. diversicolor</i>	23.8	3.5	14.3
<i>E. maculata</i>	21.2	2.8	12.6
<i>E. paniculata</i>	17.1	2.8	10.3

E. globulus, *E. diversicolor* and *E. maculata* all had diameters at breast height over bark [DBHOB] greater than 20 cm in 7 years. It seems likely that by 20 years all three species will have large end diameters [LED] of 40 cm or greater. Forty centimetres LED is the minimum size of hardwood logs being sawn in the VALWOOD process [CALM, 1989].

In the case of *E. globulus* the rotation time may be as short as 15 years. The DBHOB of 7.5 year old *E. globulus* was 29.5 cm and the DBHOB increment in the seventh year was 4.9 cm/yr. By 15 years the DBHOB can be expected to be 50 cm and by 20 years, 65 cm [assuming an annual DBHOB increment of 3 cm]. The new milling and seasoning technology developed at the Wood Utilisation Research Centre at Harvey now makes it possible to use hardwood logs of these sizes and ages to produce VALWOOD.

The time of harvesting trees from a widely-spaced stand is flexible. All or a proportion of the trees can be harvested at any time, once they reach sawlog size. It is likely that sawmillers would be interested in buying quite small numbers of logs at a time because they would be of high quality. In the case of pine it pays to leave trees until they are 25 years old because under the present pricing structure in Western Australia a higher price per cubic metre is paid for trees over this age.

Conclusion

Wide-spaced agroforestry broadens the rainfall range over which trees for timber can be grown. In most situations producing timber is secondary to improving water quality and preventing wind erosion. However, if trees can be arranged in ways that fit well with farming, then farmers are much more likely to manage the trees for timber as well.

For implementation to be successful, farmers need more than information about how much it costs and what the returns are likely to be. They need to make agroforestry part of their farming practice. There are signs that this is happening. Farmers are modifying the traditional layout to suit their style of farming. Strips of wide-spaced trees and a range of timber species are some of the innovative ideas being tried. It is encouraging to see these steps being taken – steps which are crucial to the development of timber production as an integral part of farming systems with trees.

Agroforestry in the Great Southern

As a result of Richard Moore's visit at the Byenup Hill Catchment field day a large demonstration of wide spaced eucalypts is being established in the Carlecatup LCD. Richard Moore and other Cathall officers are providing species selection information based on soil and water quality and layout. The current details of his site are outlined below.

References

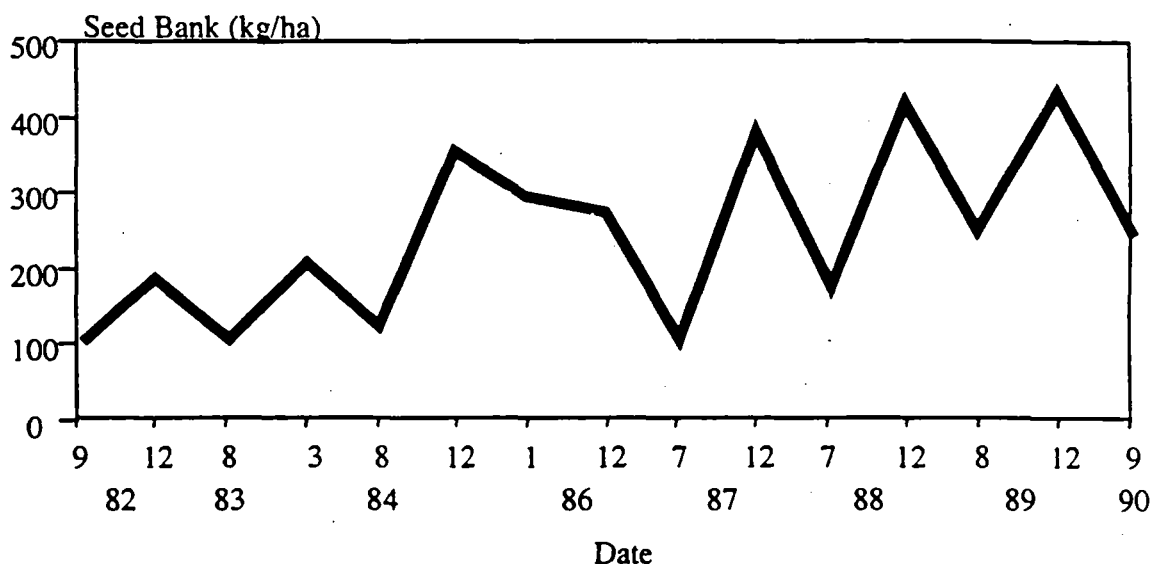
- Anderson, G.W., Moore, R.W. and Jenkins, P.J. [1988]. The integration of pasture, livestock and widely-spaced pine in South West Western Australia. *Agroforestry Systems* 6: 195–211.
- CALM [1987a]. Pine trees for timber under WA conditions. Information Sheet No. 2–87.
- CALM [1987b]. Agroforestry – an alternative approach to farming. 12pp.
- CALM [1989]. Valwood, New Wood. *Landscape*, Vol. 4. No. 4. pp. 24–27.
- Malajczuk, G., Morrison, D., Havel, J., Anderson, G. and Moore, R. [1984]. An economic study of agroforestry in the Manjimup region, Western Australia. Forests Department of Western Australia. Tech. Paper No. 10.
- Moore, R.W. [1986]. Timber production from wind-breaks in the Esperance region. *Trees and Natural Resources*, Vol. 28, No. 4, Dec. 1986.



APPENDIX 6

Pasture watch

Seed bank management is an essential element of high water use in the pasture phase of the rotations as high plant densities would give optimal growth which in turn, results in increases in water usages. **1000-2000 annual legume seedlings per square metre** are considered necessary to compete with weeds and form a productive pasture. 15% of the subterranean clover seed population is accounted for as seedlings each year. Subterranean clover loses at least half its seed reserves between early summer and winter. The graph below shows the average fluctuations of the seed bank on 17 paddocks of the Great Southern. The summer peak is followed by a winter trough. The overall trend shows an increase in seed reserves.



A range of circumstances, both during the growing season and in the summer can alter the seed bank of a pasture. The most important are:

1. **Season and soil type** which highlights the importance of species cultivar and selection of a self regenerating legume.
2. **Seed dormancy** or level of hard-seededness of the selected cultivar.
3. **Grazing management**, especially in the first year will have a large influence in seed production. Seed yields have been found to be higher where grazing has continued up to half way into flowering in subterranean clover.
4. **Cultural practices** such as weed control with a 'knock down' herbicide before sowing, and controlling grasses in the crop or pasture phase with selective herbicides, should improve pasture establishment and seed yield. Fertilisers, especially superphosphate, will benefit the legume component. Tillage operations, which bury the subterranean clover seeds and return them to the surface in later years can spread the seed population over a long time.
5. **Rotation** of at least two years of pasture should precede each crop phase when using subterranean clover. Occasional cropping is necessary so that the nitrogen fixed by the legume can be used profitably and the incidence of weeds reduced. Results from 17 farm paddocks in the Great Southern showed a reduction in the seed bank of subterranean clover, after one years cropping, of 70%. The remaining seed produced good regeneration.

A good legume seed bank will produce dense pastures which will improve winter production and pasture quality. These pastures will fix nitrogen which will, if cropping is done at the right time, improve crop

production. The pure legume swards will also reduce the incidence of take-all in subsequent cereal crops. The improved legume pasture has potential to use all of the rainfall between May and October.

Pasture strategy

Improve and maintain legume seedling rates (1-2000 plants/m²) through improved pasture management

Pasture water-use target:

All of the growing period's rainfall (see below) i.e. 315 mm assuming 450 mm annual rainfall.

Maximum water-use for pastures (based on local data including records from Roger Bilney's paddock on the Cook Road) for every 1 mm of rainfall used during the growing period an optimal 28.6 kg of pasture dry matter is achievable. This would go close to reducing the water deficit **recharge**.

This can be calculated using the formula below:

$$\text{DM (kg)} = 4382 + 28.6 \times \text{rainfall (growing season)}$$

i.e. with 315 mm used a DM yield of 4627 kg/ha is achievable.

Water that is not accounted for by the pastures will become recharge to the groundwater table. Unless it is **intercepted** by higher water-using, and deep rooted plants, such as trees.

Pasture improvement

Paddocks that are targeted for improvement may fall into one of the following categories:

1. Rejuvenating pastures (25-100 plants/m²)

The careful herbicide manipulation of the grasses to allow clover to re-establish. Apply 750 ml of simazine for heavy stands of silver grass and barley grass, including 500 ml of Sertin, if the rye grass also requires control.

2. Resowing pastures (25 plants/m²)

Need to treat the resowing as a crop. Select the cultivars. Suitable species of subterranean clover include Juneec (5 kg/ha) and Seaton Park (5 kg/ha) with 150 kg/ha superphosphate. Grazing may begin two months after sowing until flowering begins (mid September) to allow a good seed-set. The following year 'normal' grazing continues. If cropping is not an objective then rye grass may be included (5 kg/ha). With the resowing, insect control, Rogor (80 mL/L) one week after sowing or LeMat (60 mL/L). The effect of two consecutive cereal crops will seriously deplete the seed bank (see graph). However the build up of nitrogen in the soil will benefit a rotation that follows with either a cereal or canola crop.

3. Small seeded annuals like Persian and Balansa clovers grown in their specific niches such as water logged areas should help fill the summer feed gap, raise the soil fertility, compete with the rubbish grasses (ie. barley grass and Guildford grass) and decrease the catchment water deficit.

Balansa (Paradana 5 kg/ha) is sown (May/June) onto cultivated ground and tickled with **light** chain harrows. Insecticide application of Rogor or LeMat one and two weeks after sowing is essential. Two months after sowing grazing can begin until flowering to allow a good seed set. Intense grazing can recommence (December) until the following September. Fertiliser application of 100 kg/ha Super and Potash at sowing and subsequent years 100 kg/ha and 50 kg of Potash is necessary.

To succeed, the seed must not be buried deep and the red legged earth mite must be controlled. *"If you see a mite, it's too late!"*

The Persian clover (Kyambro) offers better quality dry matter and can be mixed with Balansa (2.5 kg/ha of each). Persian clover has been shown to have equivalent feeding value to red clover, and better than other legumes in perennial grass based pastures for young sheep in summer. This mix or Balansa alone provide a productive and essential legume when perennial grasses are being grown in niches with it (see Perennials).

APPENDIX 7

Eucalyptus wandoo : Regeneration in the wheatbelt

Distribution of wandoo

Eucalyptus wandoo (white gum) originally had a wide distribution throughout much of the dry and extra dry mediterranean in the south-west of WA. It is classified as a dry savanna open woodland with much of its distribution influenced by soil type and topography (Bear, 1990).

Wandoo is restricted to elevations between 210 and 340 metres above mean sea level, and the isohyets of 350 mm and 1000 mm mean annual rainfall (Capil, 1984). Outliers are found near Three Springs, Moora, Narrikup and even in a small stand 140 km east of Laverton.

Due to similar appearances and the use of common names, the main species, *Eucalyptus wandoo* subs. *wandoo* (southern wandoo) is often confused with other tree species. These are *E. wandoo* subs. *pulverea* (northern wandoo), *E. accedens* (powderbark wandoo) and *E. capillosa* (wheatbelt wandoo). All these species are endemic to south-western Australia.

The decline of *E. wandoo*

Due to clearing for agriculture, wandoo is only found in a few small scattered reserves, in privately owned woodlots or as individual trees in paddocks and in road reserves. There is enough evidence to assume that remaining wandoo (and similar species mentioned above) are in a general state of decline throughout the wheatbelt, for reasons largely unknown.

A number of plausible explanations include extreme salinity and/or waterlogging, compaction, residual herbicide overspray, insect attack (especially bark beetles) and fungal pathogens other than *Phytophthora cinnamoni* (wandoo is resistant to this fungus).

More general explanations of regional significance could implicate long term effects of fluctuations in weather from one extreme to another, drought and climate change and the lack of periodic fire. The cause of decline is likely to be a combination of these factors.

It is the importance of fire that is to be addressed below. Arid conditions (accompanied by more fires) that developed about one million years ago, favoured the dominance of eucalypts in Australia (Gill, 1964). Thus, interference with natural fire regimes are implicated in eucalypt decline.

Relationship of wandoo and periodic fire

Aborigines regularly burnt to attract game, before Europeans came. Before fire prevention and controlled burning were introduced in 1953, periodic autumn wildfires were likely to occur as frequently as every five to eight years in wandoo woodlands.

Some interesting observations can be made where fire has been excluded from wandoo woodland. Firstly, relatively healthy stands, where trees display good crowns and few dead branches, can actually be in a state of decline. This is because there is little or no regeneration.

Furthermore, stands of wandoo that are visibly declining (display poor crowns and dead branches) are sometimes associated with healthy species, such as *Allocasuarina huegeliana* (rock oak). This may suggest that species, less reliant on fire for regeneration, such as casuarina, are becoming more competitive and assuming dominance over the more fire-reliant wandoo.

How does wandoo regenerate after fire?

It has been confirmed by Neil Burrows (1990) that, in the Jarrahdale area, wandoo requires a hot fire for good regeneration, where hot ashbeds are created from fallen trees and branches. Vigorous germination occurs on ashbeds where soil has been sterilised and alkalised, and nutrients become more available for plant growth (Hatch, 1960). Although some wandoo may germinate off the ashbeds and where soil has been disturbed, their growth is poor compared to that on ashbeds. Ideal burning times are in autumn and seedfall from wandoo trees is

stimulated directly after burning by the heat of the fire. There are several conditions required, however, to ensure that wandoo regeneration is successful.

Wandoo regeneration trials in the south wheatbelt

Conditions required to achieve fire regenerated wandoo in Jarrahdale may not necessarily apply to the southern wheatbelt. There are distinct variations in climate and rainfall, and Jarrahdale represents the western extremity of the wandoo range.

For further information, Jack Mercer can be contacted on (098) 41 5205.

Funding of \$9,220 has been received by Jack Mercer to carry out the North Stirlings Landcare Project entitled 'Regeneration of Eucalyptus Wandoo in Farmland Remnant'. The funding was from the 'Save the Bush' program which is a National Parks and Wildlife initiative. Some initial trials were run on a voluntary basis during 1992.

Trials were carried out within a disturbed remnant on Hams' property, where remaining wandoo and flat-topped yates were in association. The site was prepared in March and burnt in April. Hand seeding took place in late May.

Variation in trial plots (24 in total) were as follows:

1. Undisturbed ash beds (six in total, three herbicide treated). Old logs that had accumulated from previous clearing and from tree deaths were used as fuel. These were burnt under appropriate weather conditions.
2. Disturbed ash beds (six in total, three herbicide treated). Wood fuel was prepared and burned similarly to undisturbed beds and then scarified to spread ash over a larger area of soil.
3. Disturbed soil (six in total three herbicide treated). No ashbeds were involved with these plots. The soil was simply disturbed through scarifying before seeding.
4. Controls (six in total, three herbicide treated). The ground was left as it was except for the herbicide treatment and seeded along with the other plots.

Seed was collected from a number of sites on Hams' property. Germination trials in March showed that this seed had 90% viability, with most germination occurring within 14 days. Germination at Hams' trials occurred after significant rains (27 mm) on August 27, more than three months after seeding. At this stage germination appears to be generally restricted to undisturbed and disturbed ashbeds, with very few germinants off the ash laden soils. No germination occurred on the plots that were scarified or left as controls.

Briefly the preliminary trials have given some answers. The most important points are:

- Autumn fire is an important mechanism for regeneration of *E. wandoo*.
- The ashbeds were not subjected to winter weed invasion. Spring weed germination was also absent on ashbeds, virtually eliminating initial plant competition to between wandoo seedlings.
- At this early stage, seedling growth on ashbeds appears to be particularly vigorous. Alternatively vigorous weed growth occurred on scarified unburnt plots that were not herbicide treated.

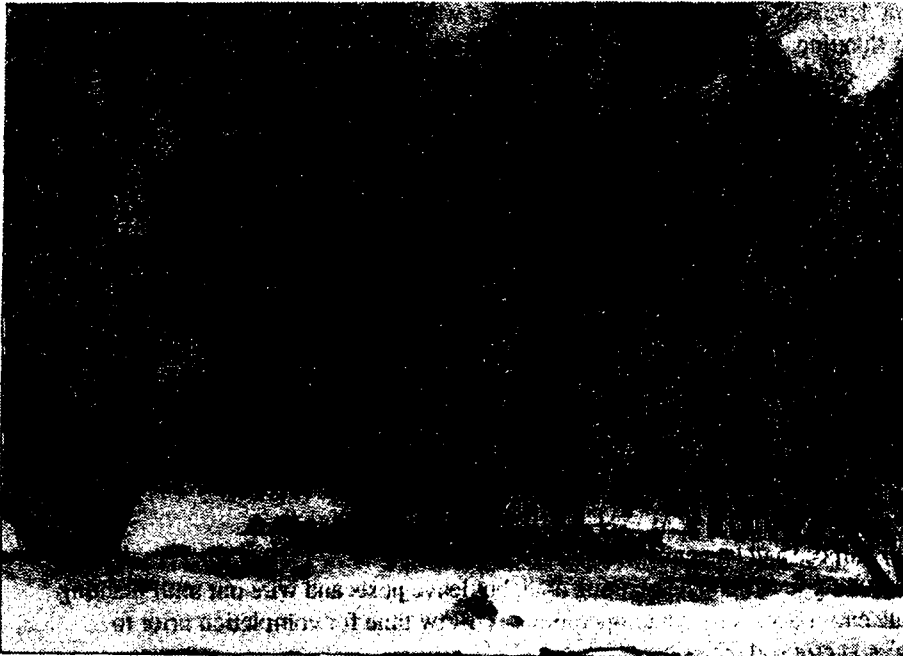
Some answers however created more questions. For instance – why did germination not occur much earlier than August? Theoretically wandoo seed had good viability and significant rains (18 mm) fell on May 23, which was less than a week after plots were seeded. A wetting followed by a drying period may be required for wandoo germination under natural conditions.

Germination of seed was much less than expected. A number of assumptions will be tested within the funded program this year that may shed light on this anomaly. Seed consumption and collection by birds and ants may have contributed to less germination.

The long term aim of the preliminary and funded trials is to establish a time-efficient and cost effective means of bush regeneration that farmers can carry out with their own resources.

References

- Beard I.S. (1990). *Plant Life in Western Australia*. Kangaroo Press, Kenhurst, NSW.
- Burrows N. *et al.* (1990). Regeneration of *Eucalyptus wandoo* following fire. *Aust. For.* 53 (4):248–258.
- Capill L.G. (1984). *Wandoo Woodland Conservation. A proposal for a system of ecological reserves.* Campaign to Save Native Forests (WA).
- Hatch A.B. (1960). Ashbed effects on Western Australian forest soils. *W.A. For. Dept. Bull. No. 4*, pp 2–20.
- Gill A.M. (1964). Fire and the Australian flora: a review. *Aust. For.* 38(1): 4–25



Sheep shelter under an unprotected mature wandoo clump at Korong Vale.

APPENDIX 8

Tree establishment- planting, preparation and planting

1. Site assessment

a) Check for:

- Soil type texture (see LMS Farm monitoring Handbook)
- Presence of shallow rock, particularly granite, (affect on moisture availability, hence species and planting density).
- Depth to hard pan. Compaction layers in light soils, depth to clay in duplex soil will determine type of machine for ripping.
- Available moisture, is site water gaining?
- Are there limiting levels of salinity in soil or subsurface waters?
- Susceptibility to flooding, (note water movement potential), identify waterways or sheet erosion risk on slopes.
- Note dominant and problem weeds.

b) Evaluate your needs or preferences for future use of the area to be planted

- e.g. dedicated to trees for long term?
- Timber production aim?
- Fodder system?
- Agro forestry?
- Habitat for wild life?
- Livestock management in the area?
- Amenity/aesthetic value?
- High water use aim?

2. Organise fencing

- Consider required purpose and longevity of fence - design factors.
- Strainers can go in early to demarcate planting area, but leave posts and wire out until planting time to facilitate easier access for other operations. (Allow time for completion prior to planting) - unless in cropped area.
- Electric fencing is the cheapest, most flexible option.

3. Site preparation

a) Ripping

- allows access for water penetration and accumulation.
- creates easy path for rapid, deep root growth.
- ensures survival in first summer and stability in strong winds.
- shatter subsoil, good traction, less compaction, not boggy (best done in summer/autumn)
- *Rule of thumb? - deeper the better! Light soils should be ripped at least 45 cm, heavy soils need dozer ripping, aim for 80 cm. Be careful not to create erosion hazards. (Safe working limit for soil conservation work is 0.5 - 1.0% slope.)*

b)-Mounding

- Should **always** be done on sites prone to waterlogging.
- *Rule of thumb? - If in doubt, mound. Mounders are available for hire from local LCDC, require a tractor of about 80 hp with 3 point linkage.*
- Kill weeds like couch, kikuyu, sorrel **before mounding**, burying rhizome of these plants in mounds makes control difficult afterwards, as they will emerge.
- make sure moulder has a press wheel fitted to help eliminate air pockets.
- mound straight after ripping and leave to settle before planting.

c) **Weed control**

- Very important, do not underestimate the competition from weeds. Probably the single biggest cause of failure in tree planting, due to capture of moisture and nutrient.
- Can be mechanical, chemical.

(i) **Mechanical**

- Scalping: beware of waterlogging or creating waterways.
- Scalp then mound subsoil. Remember to compensate for nutrient loss (no top soil).
- Cultivation, may require several passes and some hand weeding after planting, difficult in wet areas.

(ii) **Chemical (herbicide)**

- Timing is critical, target plants must be actively growing for knockdown.
- Watch the weather.
- Spray topping year ahead can reduce rates required later.
- Use a mixture of knockdown and residual.
- Ensure gear is in good condition, adequate agitation (often overlooked) and properly calibrated.
- Strip spraying:
 - * lessens chemical use;
 - * lessens erosion risk;
 - * reduces insect attack on trees.
- Ensure a suitable withholding period has elapsed before planting trees, as high rates of residual chemical can be toxic to trees. Allow at least 50 mm of rain and 2 weeks.
We would use rates in the order of :
 - 8–10 L/ha of simazine
 - 0.5–2 L/ha of glyphosate 360.Add an adjuvant to overcome any incompatibilities between chemicals (Boost, Liase etc).
Add wetting agent.
For dock, a major problem weed in tree areas add 5–7 g/ha of Brushoff.

This is an example only. Prescriptions for herbicide use vary from site to site depending on soil type, rain fall, weed type and size, timing and type of season, trees to be planted.

Use adequate safety gear. This includes gloves, breathing protection, impervious apron or overalls plus boots. Use when handling as well as spraying and mixing. The long term health effects of many of these products is still unknown.

All this and still no trees planted!!

f) **Planting**

With all these things done– planting should be quick and enjoyable. Hand planting is efficient and can involve family members and visitors. It can be therapeutic.

- Potti putki is a good tool; but wedge or a spade can be just as effective.
- Make sure plants are set the right depth (don't bury the stem part of the trees, don't leave any soil/root ball exposed).
- Heel in well.

g) **Fertilise**

In most situations trees will benefit from a spot application of fertiliser at planting; or 4–6 weeks after. Bury about 50–100 g Agras/DAP (150–200 mm from tree, 50–100 mm deep). Note the lid off a spray pack holds about 100 g.

GENERAL POINTS (in no particular order!!)

Don't cut corners

Tree planting is expensive and time consuming and often **permanent**. If done properly it is an effective treatment for many farm problems and a satisfying job. Better to take on a small area in each year and do it properly – learn the ropes.

You would not expect to grow a first grade crop or animal on second rate land – however this is the expectation many people have of trees. For example, you will be unlikely to grow high value timber on salty barley grass country.

A productive soil for good tree growth is typically well drained at surface, deep, loamy and has fresh ground moisture accessible to roots at depth.

There are alternative species suitable for most site types and land use requirements. Search them out.

Consider layout options, system stability, nature conservation values.

Recognise that minimum areas may be needed for low value timber crops (pulpwood) to be a viable investment. Distance from a market source is a critical factor, except for high value products.

Smaller areas might be better targeted for longer term timber for use on the farm (fuel wood/fencing etc) or high value, longer rotation timbers.

Financial assistance with planting of short rotation pulpwood may be an option where large areas need to be attacked with big volumes of trees and a return is needed in the short term to offset loss of grazing/cropping land.

ALWAYS site trees with regard to your whole farm plan. Make your plantings multi purpose.

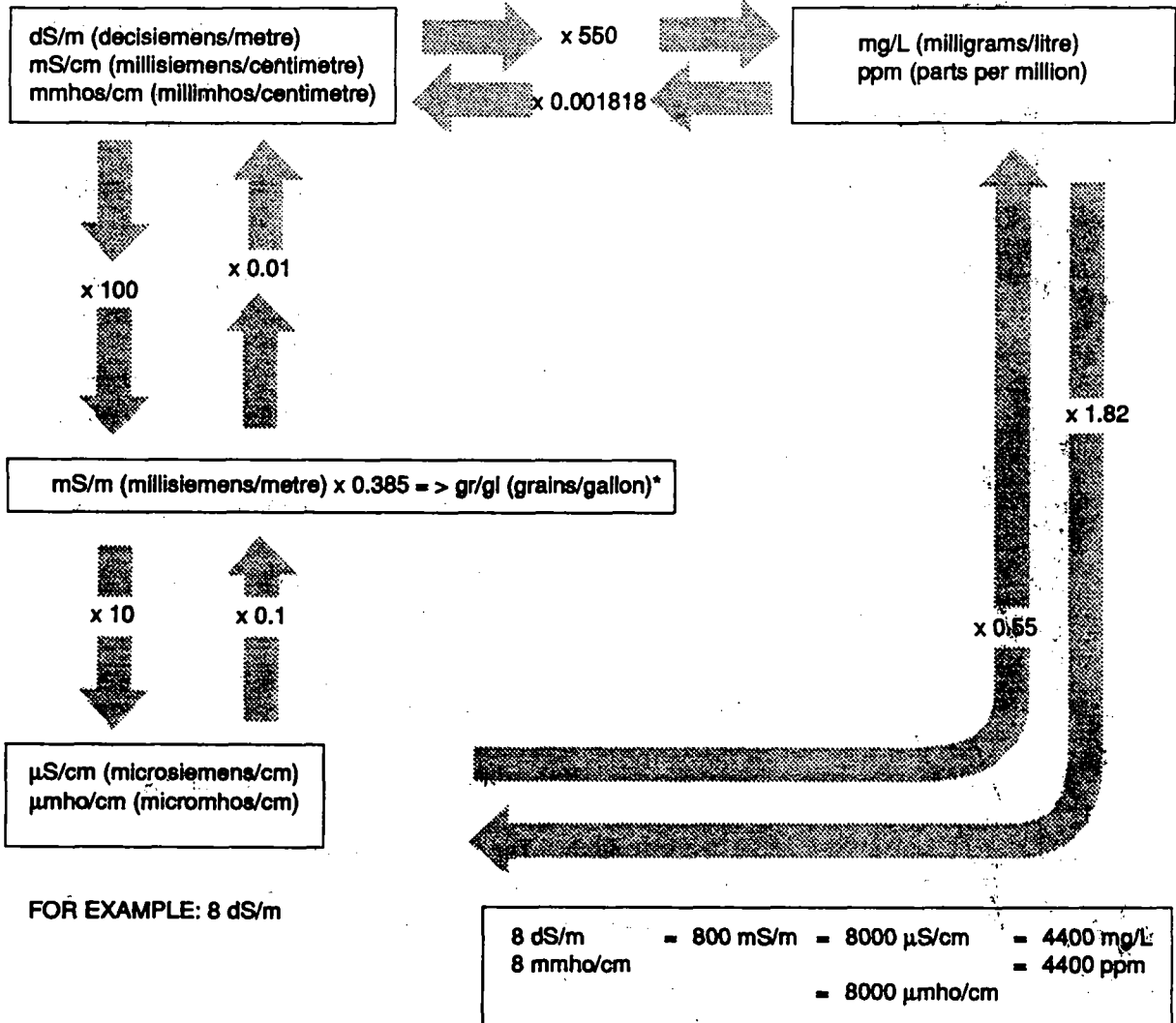


Seed collection from native bush in a neighbouring catchment.

COMMON ELECTRICAL CONDUCTIVITY (EC) MEASUREMENT CONVERSIONS

Units used to measure salinity:

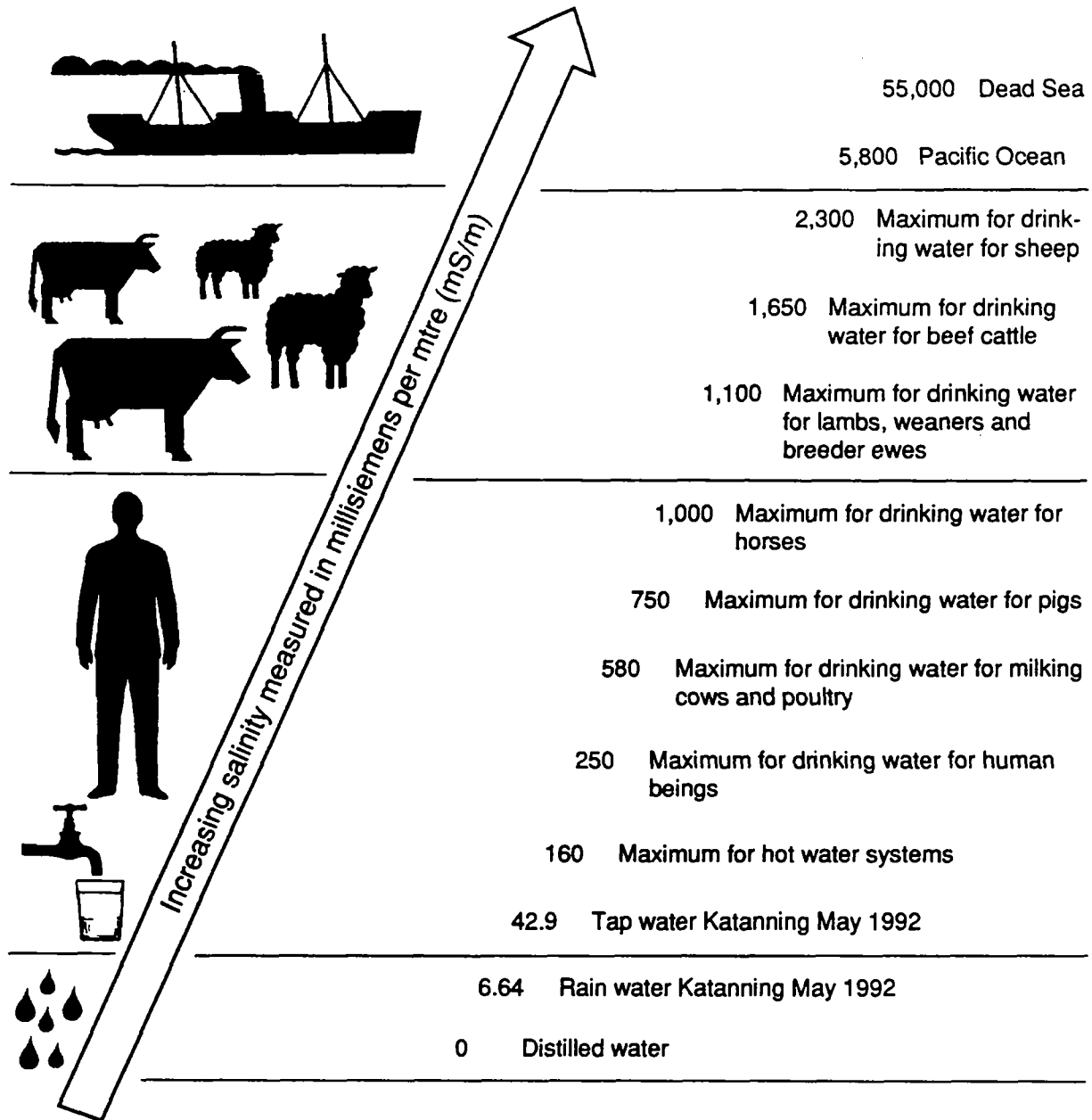
There are a number of different measures of electrical conductivity and hence, salinity. There are various reasons for this, including historical precedents, compatibility with historical groups or simply personal preference. These measurements do not account for the effects of different chemicals (ions) in solution.



* Grains per gallon (gr/gl) is a measure previously used and still referred to by some landholders, it is weight of salt remaining after evaporation of water. For many years most gr/gl measurements have been estimated by using electrical conductivity measuring meters.

Adapted courtesy of Department of CALM, NSW

EXAMPLES OF WATER SALINITY LEVELS AND RECOMMENDED MAXIMA FOR DOMESTIC AND FARM USE EC (Electrical Conductivity), mS/m



Prior stream sands land management unit

Identification

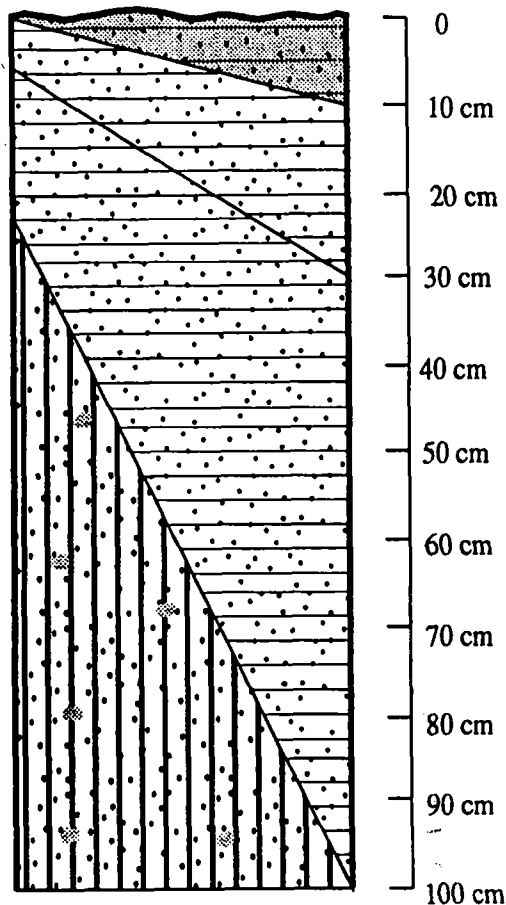
A sandy, loamy sand loose and non wetting topsoil, overlying a deep bleached horizon to clay. This clay is not easily reached with an auger.

Landscape and vegetation

This is an important land management of the Carlecatup river flats (lower sub-catchments from Byenup). Formation from deep, sandy river sediments that have been transported and deposited by the river itself as it has altered its channel with time. Marri, Banksia and Christmas tree and huge diversity of lower storey species characterise these soils. Much of the remaining vegetation in the Carlecatup occurs on uncleared Prior Stream Sands.

Soil description

- A11 Very dark greyish brown (10 YR 3/1)
Abrupt boundary
Loose grained
Loamy sand
Non wetting surface
Neutral (pH 7.0)
Low organic matter
- A12 Brown (10YR 5/3)
Gradual change
Loam sand
(coarse/medium grain size)
Loose and single grained
Small amount fine quartz (1%)
Neutral (pH 7.0)
- A2 Light yellow brown (2.5YR 6/3)
Loamy sand
Loose, single-grained
(course/medium/fine)
Small amount of quartz (0.5%)
Neutral (pH 7.0)
- B Sandy clay (yellow brown 10YR 6/4)
Yellow/orange mottling
Neutral (pH 7.0)



Variability

Generally appear in dune systems running along side the main waterway. Often salt-affected land occurs between these sands and main waterway. The depth to 100 cm clay may vary, however generally a deep sand occurs. These soils may be confused with the marri duplex soils that occur on the gentle slopes. They can be prone to 'blow' in summer and have a high recharge hazard. Often make good fresh soaks.

This Land Management Unit has been identified on the lower sub-catchments of the Carlecatup. For this reason and that it is a major LMU, it has been included in the Appendices of this report.

BUDGETING THE CATCHMENT WATER BALANCE

Introduction

"Planning Your Enterprise Mix" on page 15 of the Byenup Hill Catchment Report outlines how MIDAS has been used in this catchment plan. Using MIDAS the optimal enterprise mix on a farm was established (see the MIDAS graph on page 17).

The results have been extrapolated to a catchment, using the Land Management Units and their total areas (hectares) as they were identified and mapped by the farmers.

The model was used to provide a guide for the economic optimal area of crop in the catchment. From these areas the amount of water used by crops and annual pasture has been determined (see table below). The deficit in water-use has been "taken-up" with the perennials and trees. However MIDAS makes no consideration for trees and perennials in calculating the economic enterprise mix.

The table shows the breakdown of the water-use by selected plants to achieve a catchment water balance, (ie. to 'take-up' the annual rainfall volume of 1.53 million cubic metres).

Continued page 2

Byenup Hill Catchment Group

	Members	Farms	Telephone No.
1.	Ian and Sue Palmer Jim and Lucy Palmer	"Cranham"	(098) 25 3090
2.	Alan and Lorelle Goodall	"Korong Vale"	(098) 34 1046
3.	Roger and Marie Bilney	"Forts Valley"	(098) 34 1012
4.	Dave and Lyn Mathwin (David Potts) Graham and Sheila Blacklock	"Barrule" "Tracey's Tree Nursery"	(098) 31 1761 (098) 31 1365
5.	Geoff and Glenis Reinke	"Doodledup"	(098) 25 3082
6.	Mal Anderson (Brown and Betty Parnell)	"Crathie"	(098) 25 3075

Benefits of a water balance study

The "increasing water use" strategies illustrated by this catchment study are dependent on an even distribution of perennial plants. By protecting the existing bush (approximately 5% of the total area) and the establishment of 'new' tree plantings (approximately 5% of the total area) strategically placed with perennials (approximately 12% of the total area) the commercial productivity of the catchment is preserved.

This water balance has been designed for the total catchment from a design point at the culvert on the Graham's Well Road. The strategies have been calculated assuming the catchment is a single groundwater compartment and managed as a single unit ignoring existing farm boundaries. It is recommended that this accounting procedure is used at a more local level (with specific design points) where discrete 'parcels' of land, can be identified, such as sitting behind dolerite dykes. These may be contained and managed on one farm alone or may require a co-operative approach such as on a major tributary. Calculating the water balance is a crucial step for planning to control recharge for every catchment.

Monitoring

It is important to review progress by recording the landuse changes in the catchment over time, such as adding each new hectare of trees, perennials, continuous crop to a data base (such as 'Landkey') each year. This will ensure the focus on optimum water-use remains. In addition, reviewing progress allows new technology and management to supersede and enhance the current strategies.

In summary

The Byenup Hill Catchment plan lists **five objectives** with *outcomes* and *actions* concerning the following topics: Water balance; Conservation works; Nature conservation; Catchment planning and Monitoring. As the catchment environment changes the benefits of having preserved and enhanced the remaining fragments of the natural bushland becomes increasingly apparent. The local diversity increases which improves the resilience of the biological systems to change. The catchment plan has provided an opportunity to begin to model the agricultural systems on the natural ones to help ensure they are sustainable.

Landuse	Total Area Of LMU Groups And The Optimal Water-Use										Total Catch't Water Use (%)		
	Marginally saline land		Waterlogged sands		Deep sand		Sandy gravels		Sandy loams				
	Total Area (ha)	Total Water-use (%)	Total Area (ha)	Total Water-use (%)	Total Area (ha)	Total Water-use (%)	Total Area (ha)	Total Water-use (%)	Total Area (ha)	Total Water-use (%)			
Continuous cropping (*23%)	-	-	-	-	-	-	-	765	18	-	-	-	18
Annual pasture (*56%)	-	-	-	-	-	-	1146.5	24	678.5	14.7	38.7	-	
Perennial pasture (*12%)	130.2	4.3	235.9	7	8.8	1	-	-	-	-	-	12.1	
Existing bushland (protected) (*4.9%)	38.9	3.5	12.8	1.1	-	-	48.8	4.24	60.9	7	15.84	-	
Windbreaks and upper slopes trees (*2.8%)	-	-	-	-	-	-	61	7.5	31	4.4	11.9	-	
Wide-spaced agroforests (trees) (*0.7%)	-	-	25	0.9	-	-	-	-	-	-	-	0.9	
Alley farming (trees) (*0.6%)	20	2.9	-	-	-	-	-	-	-	-	-	2.9	

* = % age of the whole catchment