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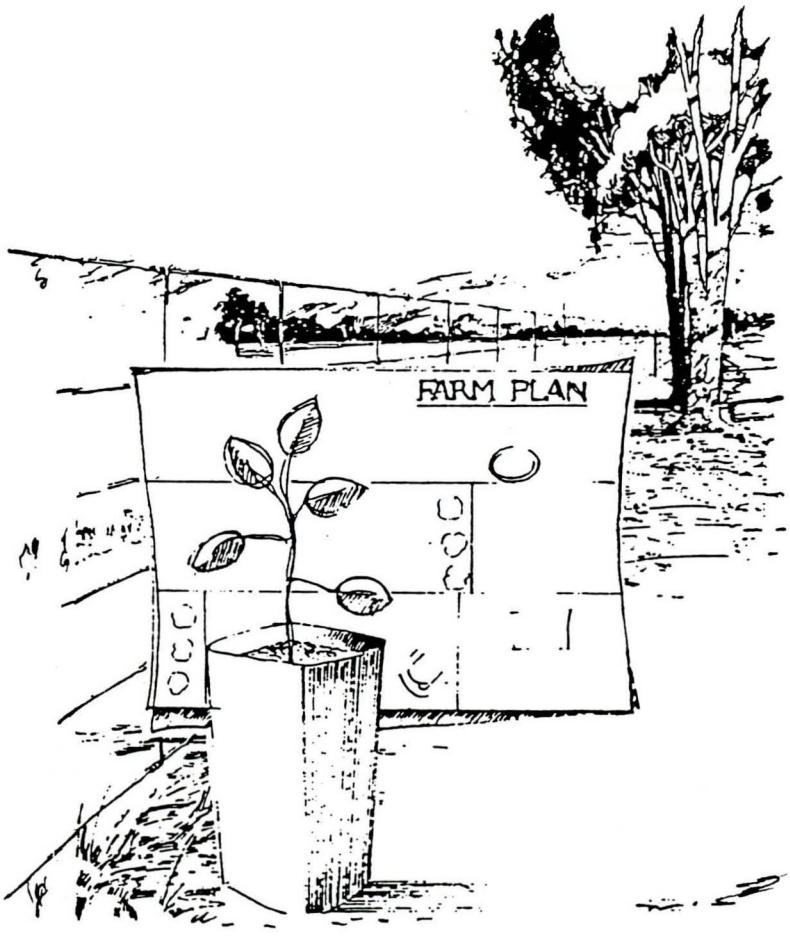
Farm Planning Workshop Manual

Brian Lloyd

FARM PLANNING WORKSHOP MANUAL



compiled by Brian Lloyd,

DEPT. OF AGRICULTURE,

KATANNING.

DEPARTMENT OF AGRICULTURE
WESTERN AUSTRALIA

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FARM PLANNING MANUAL

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PREFACE (3rd Edition)

The Katanning District Office of the Department of Agriculture has been running Farm Planning Workshops since 1988. These group sessions evolved due to an ever-increasing demand for individual farm plans to be drawn up by departmental staff - a demand that eventually out-stripped the ability of staff to supply the plans on a one-to-one basis.

This manual has been complied to supplement the workshop sessions. It comprises:

The Farm Planning Manual:

Notes written by various officers of the Department on factors to consider when drawing up a farm plan.

Reference Material:

Selected notes on various topics that have proven to be of interest to farmers in the Great Southern Region in the past. Many of these notes may only introduce a topic, and further information is available from offices of the Department, upon request.

ACKNOWLEDGEMENTS

This manual consists largely of articles from officers of the Western Australian Department of Agriculture, whose contributions are acknowledged individually.

The use of excerpts from the booklet titled: "Conservation Farm Planning" by W.J. Burdass, T.R. Negus and E.J. Roberts, is also gratefully acknowledged.

The reference material contains, amongst other articles, a reprint of Departmental Bulletin 4206 "Trees For Farms".

Brian Lloyd
Workshop Co-ordinator
Great Southern Agricultural Research Institute
Katanning

INTRODUCTION - Brian Lloyd

Welcome to the Farm Planning Workshop. The aim of the workshop and this associated manual is to help you, along with your neighbours, to evaluate your land, and develop a whole farm plan.

By the end of the workshop, you may not have "finished" your farm plan, however, you will be aware of factors to consider when drawing up a farm plan, and you will know where to get help to solve specific problems should they arise.

Really, there is no such thing as a "completed" farm plan, as it should be an ongoing, dynamic plan. It should be possible to alter it later if situations change such as new markets open, new technology, etc.

It is also worth noting that there is no one "correct" farm plan. Different people could come up with different farm plans for your farm, all equally "correct." However, they may have a different emphasis. Because you are drawing up your own farm plan, you can build your own preferences into the plan.

Also remember it is very useful to seek others opinions on your plan, as they look upon your farm with a different perspective.

I am confident nearly all farmers are able to draw up their own farm plans, with guidance. After all, you know your farm better than anyone else. You are the ones that have seen it flooded, worked up, blowing, producing good crops, etc. What you get out of this workshop is directly related to what you put in both at the workshop AND afterwards .....so work at it. It's <u>your</u> farm.

REASONS FOR PLANNING YOUR FARM - Ashley Prout

The preservation of our land in a high state of production, by ensuring that it is not used beyond its capability and that it is sufficiently protected against erosion is vital. In addition, the planned operation of the farm as a business proposition is essential to economic production.

Farming is just as much a business as running a supermarket or manufacturing tractors. There are two parts to the financial factors involved.

1. Invested capital. In the case of the farm the majority of invested capital is in the land, or more currently in the SOILS. If the soil is being lost by erosion, the owner is living on his capital. On the other hand, the soil can be preserved and its capital value increased.

2. Returns to investment or dividends can be maintained or increased. This requires that the land be managed in such a way that its productivity is maintained and where possible increased.

Management of land rests mainly on the fact that its productive capacity depends on such factors as climate, soil conditions, slope, susceptibility to erosion and other physical characteristics.

Management should aim at using every hectare towards gaining the greatest return without injuring the capacity of the soil to produce. To achieve this, detailed planning of the farm is required so that each part of it is used to best advantage, and any soil conservation practices are applied wherever necessary.

Good planning may be described as a system of land use which allows PROFITABLE PRODUCTION PERMANENTLY.

Such a system must involve:-

a) Fertility building - for profit;
b) Stability - for performance;
c) Good design - for efficiency

Conservation planning must be realistic and take into account the hopes and financial situation of the farmer concerned, as well as the needs of the soil. A plan is a way in which the farmer can achieve what needs to be done to conserve the soil on his farm, in an orderly manner. It is a blue print for future physical developments and a guide to future land use.

Reasons for planning in practical terms include:

* The need to change land use because of degradation such as salt or erosion.

* A change of ownership - the new owner may have different needs or wishes to become involved in different enterprises which necessitate the need to change the fencing layout.

* Farm build up - newly acquired land must be added to the existing holding.

* Intensification - requiring that smaller paddocks are fenced for better grazing management.

* The development of irrigation potential.

* The adoption of new technology - e.g. the identification and special management of ground water intake areas.

* Changed economic circumstances which cause enterprise change e.g. more cropping - shorter rotations.

* Tree planting on a large scale.

Old and New Farm Plans

a) **Replanning Old Farms**

Replanning old or developed farms is certainly harder than starting from scratch. Usually the farm is fully fenced, the homestead, yards, sheds, etc are fully established and water supplies, shelter, etc may be adequate.

Usually fences are erected around patches of clearing as they occurred, dams are sited to provide water for the stock and houses and sheds are erected for convenience. Access can be a nightmare.

A problem arises in planning developed farms in that fencing is of different ages and in varying state of repair and replacement is a very expensive exercise. In these cases a farm plan is usually drawn up for long term re-development and many compromises are made.

Mistakes made in the early development years are usually very obvious. Since you have been living with them for years, they may have become insignificant to you by now, however this still amounts to loss of production. A farmplan will give you a structured framework within which over time, these inefficiencies will be eliminated.

b) **Planning New Farms**

It is relatively easy starting fresh and mistakes can be avoided. However, flexibility needs to be in built to cater for different circumstances.

The use of stereoscopes when planning new land is essential since much of it is fairly inaccessible, drainage lines and other topographic features are often difficult to locate.

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THE PLANNING PROCESS - Joe Burdass and Brian Lloyd

This will be the major portion of this workshop. It involves five stages:

1. Fact collection
2. Assessment
3. Planning
4. Evaluation
5. Implementation.

Before the planning process can begin, the backbone of the farmplan must be established.

* Your 1:10000 aerial photograph must be set up with the overlays that are provided, and these should be attached in a hinged fashion.

* When collecting the facts and doing the planning you should use your Omnichrom pencils provided.

* Be guided by the "Farm Plan Presentation" sheet that follows in a few pages and the "Farm Planning Workshop Key" which should be attached to your base photograph.

* Display the relevant facts on the appropriate overlay.

Doing these things will ensure all the relevant features are marked in a logical order.

Initially, do not be limited in planning with a fixed budget. One way or another, you will always spend money on improving your farm. Farm planning ensures these improvements complement past and future improvements, whilst encouraging sustainable agriculture. Farm planning makes the most efficient use of one of your most important resources - money. Draw the plan that is best for your farm resources, then work out a budget.

Hard as it may be, it is an important part of the farm planning process to put existing fencing at the back of your mind for the time being. NEVER try and draw up your proposed overlay whilst looking at your existing overlay. If some existing fencing turns out to be in the right spot - great. However, don't plan your farm around good fences in the wrong situations. Assume one day these fences will also need to be replaced (due to age, fire, storm, etc) and have your plan ready as to where you will re-position them, even if it is 15 years down the track.

1. FACT COLLECTION

For your farm, note:

* The type and intensity of present land use. (Overlay 3)
* The types and numbers of livestock.

* Identification and segregation of different types of land. (Overlay 1)

* Signs of land degradation- e.g. erosion, salinity. (Overlay 1)

* Water disposal problems. (Overlay 1)

* Location and suitability of water supplies. (Overlay 3)

* Location and state of existing developments e.g. fences, accessways, sheds, yards etc. (Overlay 3)

* Location and adequacy of shelter belts. (Base photograph)

* Potential for further development. (Overlay 2)

2. ASSESSMENT OF THE FACTS

Ask yourself this series of questions.

* Of a degraded paddock

  - what caused the degradation?
  - what needs to be done to remedy it?
  - will a different type of land use be:
    . more profitable?
    . increase production?
    . be less liable to cause degradation?

* Of each existing development

  - has it any further useful life?
  - is it causing any erosion or flooding problem?
  - is it hindering or aiding:
    . the efficient use of machinery?
    . efficient grazing management?
    . efficient stock handling?

* If potential for further development

  - what is needed to develop this potential?
  - how will it fit in with existing development?
  - what will it cost?
  - what will it return?

Also, consider these specific questions:

Which parts of the farm need fencing into separate paddocks?

What classes of land need different management practises for maximum profitable production and to avoid land degradation (i.e. identify Land Management Units). Some areas need special management e.g. salt land, deep sand. Are there large enough areas of non arable land to make subdivision of "grazing only" paddocks worthwhile? Refer to the "Land Management Unit" section.

Which parts of the farm need soil conservation measures?

Try to assess the cause of the existing problems - past or present land use and the present position of dams and fences is certain to be involved. Is over cropping, over grazing, poor pasture, lack of fertiliser or the right type of fertiliser the problem?

Which parts of the farm need better water supplies?

Have new dam sites been tested and is the catchment adequate? Can an existing contour bank system or a future drainage system be useful? Is clay close enough to the surface? Is there salt?

Is all weather access possible?

Maybe permanent creek crossings are needed. Is a control raceway necessary or justified? Can roads be useful for drainage? Refer to the 'Laneways' section.

Is adequate stock shelter available?

Maybe fence lines can be altered to make better use of existing bush. It may be necessary to plant new shelter belts - where is the best place for these? See 'Trees for Farms'.

How many paddocks are needed and of what size?

Possibly the hardest decision of the lot and in many cases this will be dictated by the physical features of the farm. How many sheep or cattle do you like to run together, what is your stocking rate and what should it be. How much cropping is undertaken. Is the crop for sale or feed?

When you have answers to all these questions you will then be in a position to start drawing up the plan.

3. PLAN

* plan to change land use.
* to develop unused potential.
* the position of yards, sheds, a new house.
* access for stock and vehicles.
* conservation and distribution of water.
* disposal of surplus water.
* soil conservation works.
* shelter in places where it is needed.
* additional fencing.
* sequence of implementation.

Specifically, make sure you have considered all of the following points in your farm plan:-

Good all-weather access to all paddocks, and to all contoured lands within each paddock. Consider the new stock movement pattern from the paddocks to holding yards and shearing shed. Roads, gateways and firebreaks should be located on ridges or below contour banks where they do not collect or concentrate run-off causing erosion.

Position of house and buildings - where these have not been built as on a new land property, or where a new house, stockyards or shearing shed are to be built, it is worthwhile considering alternative locations. It may be possible to locate a new house where it is more sheltered, has a better view, has better gardening soil or is less likely to be flooded. New yards can be sited centrally so that the distance stock have to be driven can be kept to a minimum.

A system of reliable drought-proof stock water supplies - aim to provide a watering-point in every paddock which holds well and fills rapidly. When replacing fencing better use can often be made of existing dam sites and bores.

Earthworks required to control or prevent erosion on land with this hazard. The most commonly used treatment is to fill any small and medium size gullies and construct graded contour banks at 80-200 metre intervals down the slopes concerned. Grade banks should not exceed 800 metres in length and should have a fall of about 10 cm in 20 metres. It is best to get a qualified person to design such systems as they will consider the total catchment, outlets, legalities etc.

Stock shelter - it is important to provide adequate shelter in as many paddocks as possible. What about planting trees on non-arable areas such as salt patches, deep sand or rock outcrops where natural bush has been completely removed during clearing?

Remnant vegetation should be fenced out to arrest its gradual decline if being grazed. Young trees will then be allowed to grow and an under-storey will also develop. Stock still get shelter from the lee side.

The new fencing layout designed to fit in conveniently with Land Management Units, the soil conservation works natural boundaries, permanent roads and to make the best use of existing and potential watering points.

4. EVALUATE

Evaluate both the plan as a whole and each component part asking:

- will it eliminate erosion? (and other land degradation)
- will it promote efficient stock management?
- will it promote the efficient use of machinery?
- what is the cost?
- what is the benefit? - increased profit - value added.
- can it be implemented with available resources?

Budgetting is also an important part of evaluation so you know the long term cost of implementation of your farm plan. This can then be broken down into a yearly budget so you know the level of expenditure required to implement your farm plan.

5. IMPLEMENTATION

- putting the plan into action.
- adjusting for unforeseen practical problems.

Implementation is dealt with in more detail later in this manual.

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FARM PLAN PRESENTATION
- Brian Lloyd

On Aerial Photograph:

Boundary fences
Dams
Drainage lines (major and minor) including dam outlets
Ridges
Remnant vegetation
Established treelots/windbreaks

On Overlay One:

Land Management Units (see below)

On Overlay Two:

Proposed earthworks (drainage, water supplies, etc)
Proposed revegetation
Proposed fencing

On Overlay Three:

Existing fencing
Existing water supplies
Existing earthworks

Features on Overlay 3 can be drawn in at home between Day one and Day two.

Overlay Three (Existing Works) may also be used for short term interim work within the next year or two if so desired.

Note:
It is important to attach the enclosed "Farm Planning Workshop Key" to your base map for future reference. It should also be completed with your 'scale' and 'date drawn' information.

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LAND MANAGEMENT UNITS
- Heather Percy

Land Management Units (L.M.U.s) are areas of land, with common soils and landforms, which should be managed similarly in order to maximise their production and minimise land degradation

L.M.U.s are used in farm planning to group together parcels of land so they can be managed as discrete units. These units form the basis of your farm plan with L.M.U.s being fenced separately, where feasible, to allow their best use.

A separate sheet describing some of the more common L.M.U.s in your area is included in the Soil Management section of your manual. This sheet describes each L.M.U. and how to identify them. Examples of L.M.U.s include salt affected land, deep sands, flat waterlogged valley floors and gravelly ironstone ridges. Also included in the Soil Management Section are some soils information sheets which are relevant to the local area. These should help you identify you L.M.U.s.

You may have different soils or landforms on your farm that do not fit in with these descriptions. It is quite feasible to create your own L.M.U., making note of its special features and implications for management. You may also wish to sub-divide the standard L.M.U.s further.

Once you have mapped the L.M.U.s on your property you should address their particular management needs. Often L.M.U.s will benefit from separate fencing, for example an area of deep sand. However this must fit in with other factors such as the size of the area, water supply and access. You should also start thinking of ways to overcome land degradation such as erosion or waterlogging. This is also a chance to review your farms productivity and to think about cropping rotations, pastures (annual and perennial) and tree planting.

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USE OF AERIAL PHOTOGRAPHY IN FARM PLANNING - W.J. Burdass (et. al.)

Aerial photographs are taken with a camera mounted in an aeroplane and are taken vertically. Photography is usually carried out on cloud free days and around midday to avoid too much shadow. The scale of the original photography is governed by the altitude of the plane and the focal length of the camera.

Photography is used in two ways for farm planning:

1. As a base map, the aerial photo provides an excellent start to the farm plan since it contains most detail. It is up to date and missing detail can easily be added. For an aerial photograph with a scale of 1:10000, 1cm = 100 metres.

2. For photo interpretation - a skill on its own that is split into two parts.

a) The terrain appears in different shades of grey ranging from black to white. These different shades are caused by differences in the amount of light reflected from various surfaces. Some commonly recurring and well defined features that can be readily defined because of this property are:-

   - Water surfaces - these absorb light readily and no or little light is reflected - therefore on the photo these areas appear dark or black.
     Broken water or glare from the sun will show as white.

   - Pasture - reflects a large amount of light and appears as a grey shade.

   - Scrub - a dark mottled grey.

   - Cultivated land - varies from light to dark depending on soil colour, angle of height and colour of crops.

b) The relief can be seen in three dimensions through a stereoscope using stereo pair photographs. This enables ridges, hills and drainage lines to be readily picked out. With a prior appointment, these are available for your use at the Department of Agriculture.

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DOT GRIDS - Brian Lloyd

An integral part of farm planning is the drawing in of potential paddocks to your farm plan, using the Omnichrom pencils supplied. As the lines left by the pencil rub off a glossy surface (i.e. your overlays), if a potential paddock doesn't suit your purposes for some reason, it can be erased very easily.

One critical factor in determining the usefulness of a "desirable" paddock is its area. As you have seen at the workshop, planimeters measure area quickly and relatively accurately. However, in later planning when access to a planimeter is not readily available, the dot grid supplied is also a relatively accurate measuring device. The bigger the dot count the more accurate the measurement. Counts of several hundred dots are very accurate. The method is simple:

1. Randomly place the dot grid over the section being measured (i.e. don't place it parallel to straight boundaries).
2. Count the dots. Accelerate counting large numbers of dots by counting in increments of five per line or twenty five per square.
3. Where dots fall on the boundary line of the area being measured, count those on the northerly and westerly boundaries and ignore those on the southerly and easterly boundaries.
4. Small areas can be counted several times using different random placings each time, and the results can be averaged.
5. Look up the scale of your aerial photograph on the bottom of the grid and multiply the number of dots by this factor.

   e.g. on a 1:10000 aerial photograph
   560 dots x 0.1ha = 56 ha

   If your scale is not on the grid it can be easily worked out remembering there are 10 dots per square centimetre.

   e.g. For a 1:8000 aerial photograph:

1cm	= 8000 cm
1cm	= 80 m
1 sq cm	= 6400 sq m
10 dots	= 6400 sq m
1 dot	= 640 sq m
1 dot	= .064 ha

Dot grids are also very useful in measuring areas of tree plantations, remnant vegetation, etc., during the planning stages.

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SITING OF STRUCTURES
- W.J. Burdass (et. al.)

Sheds, Yards, Homestead

This section applies to new farms or where consideration is being given to building new yards, house etc. Factors that should be taken into account include:-

a) Well drained site with some slope. People do not like living in a bog. Sand and gravel can be carted in to improve drainage. Drains and banks can be used to improve the site. Sites subject to periodic flooding should be avoided as should heavy clay sites and crabhole country as these soils can damage foundations. Deep sands should be avoided because of wind erosion problems.

b) All weather access from the main road is vitally important for trucks in and out and for personal reasons such as accidents etc. Poor access can be improved by forming and gravelling.

c) Proximity to S.E.C., Telephone, Water Supply. Close proximity to these services can save money, however if finances are not limiting, these services are easily extended if good sites are available.

In addition to the above, special considerations for siting the homestead include:-

a) the availability of water;

b) closeness to school bus;

c) closeness to neighbours;

d) availability of shade and shelter;

e) suitability of soil for gardening;

f) aesthetic considerations;

g) salinity problems;

When selecting sites for yards and sheds special considerations should be given to:-

a) access - the shearing shed should be placed at a point where access to various parts of the property meet. A central position reduces the time and distances involved in moving stock.

b) subsidiary yards can be used where the main yards are located at one end of the farm. Stock would then only have to be brought to the main yard once or twice a year.

c) cattle yards should be centrally located and out of earshot of the house. It is however as well to be able to supervise the access to the yards in order to control any unwanted tresspassers.

d) drainage and erosion problems frequently occur around yards and careful siting is essential. Drains can be used as can gravel to settle any dust problems etc. Wind breaks can be planted to reduce wind speeds and prevent dust and low temperatures.

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PLANNING FOR SHELTER
- Ashley Prout

There has been a tendency to clear too much of the natural vegetation - quite often this is still the case. Sound judgement is needed to match clearing with soil type and land use. An example is cropping. Clearing on non erodible soil types is acceptable for cropping. Less intense clearing on erodible soil types is acceptable for grazing and shelter. On most farms neither permanent cropping or permanent pastures is practiced and various rotations are adopted. Therefore a compromise has to be made - this is usually brought about by adopting different rotations to be practiced on different soil types in different paddocks.

Planning new land to leave adequate shelter is easy - in fact under the recent Government legislation it is compulsory. However there is not much new land left and planning for the establishment of new shelter and the protection of existing bush should be a major undertaking.

We are dealing with old land where possibly subdivision and clearing and general planning leaves a lot to be desired - NOTHING is gained by re- building fences on old alignments - everyone has to learn from their mistakes. In new farm plans advantage should be taken of existing trees. Fences should be located to protect them. It is generally accepted that shade and shelter are necessary for efficient stock production. In this area vegetation or tree plantations play a major role in the control of salinity.

The best position for shelter belts should be planned well before any fencing or refencing is done. ESTABLISH the purpose for the tree planting so that they can be located to the best advantage. As trees, tree planting and maintenance are expensive, they should be located where they will do the most good. They should not conflict with farming operations and productivity, however to enable fast growth they must be fenced from stock.

In this region the main purpose of shelter belts is to reduce the chilling effect of the wind and to combat salinity problems and wind erosion. With this in mind, windbreaks should give protection from cold southerly or SW winds. As far as salinity is concerned, trees should be planted on identified "intake" or recharge areas and also discharge areas, both as the site dictates. The destructive north westerly winds in Autumn should be a consideration when planning a windbreak to combat wind erosion.

Wind direction, effect of or the existance of natural vegetation may effect paddock size and shape. Generally, wind breaks only affect the land to about 20 times their height (eg: a 10 metre tree only protects about 200 metres) and paddock widths should be designed accordingly. Paddocks should be long and narrow with their main axis at right angles to the chilling winds.

Further information on windbreaks is available in the "Trees for Farms" Bulletin contained later in this manual.

Benefits of Shelter

Leaving natural bush or planting wind breaks 20 metres wide every 400 metres only amounts to 5% of the farm (a reasonably well accepted figure to leave as shade and shelter is 10%).

Researchers in N.S.W. and Victoria have shown that shelter can reduce lamb mortality by 50%, reduce feed intake by 40% and generally increase body weight. These results were obtained under similar wind and temperature conditions to those on the South coast. This information can be directly applied to the farm plan by increasing the amount of shelter in lambing paddocks or paddocks where pregnant ewes need hand feeding etc.

In Jerramungup, wind erosion can cost up to $20 per hectare on a 1 tonne crop when 4mm of dust are removed. Further information on wind erosion is in the "Soil Management" section in the reference material.

Shelter in cropping paddocks reduces the risk of wind erosion and the necessity to replant and the following lower yields.

However it is important to remember that it is what happens between the shelter belts that has the most effect on the farm's productivity.

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FENCING LINES, PADDOCK SIZE AND WATER SUPPLIES - W.J. Burdass (et. al.)

Subdivision Fencing

The siting of fence lines along natural topographical and land management units reduces erosion hazards because cultivation and other farm activities e.g. spraying, top-dressing and stock movements are complimentary to those natural features.

Typically we recognise that drainage lines, farm roads and other barriers to cultivation are ideal fence lines and that this type of fencing allows the farmer to keep reasonable sized lands to work.

1. **Land Management Units**

   It is often very beneficial to fence to land classes as they will require different management practices. As previously discussed, this is a major consideration in farm planning.

2. **Fences along creeks and natural depressions**

   Fences should not be put so close to a depression that water flows on the fence line itself nor should it be put so far from the depression that an area of ground large enough to be cultivated is left between the fence and the centre of the depression. In most cases this means fences need to be sited 10 - 20 metres from the centre of the depression. Where depressions are flat and ill defined this distance will need to be increased. With respect to drainage and stock movement, the fence should be placed so that stock no not trample the drainage line.

3. **Fences on the contour**

   The position of the fence in relation to a grade bank should be such that the fence line goes below the bank with sufficient space between to allow for maintenance of the bank with mechanical equipment.

   Where there is no grade bank, the fence should be placed on a line surveyed with a fall of about 10 cm in 20 metres with the fall being in the direction of a natural depression on waterway.

4. **Fences on ridges**

   Fences on ridges should follow the crest closely particularly when associated with a main accessway. Where the exact position of the crest is not obvious to the eye, it can be located using a level.

   When a laneway is to be constructed on a ridge the fences may have to be constructed a little off the crest itself - though any track associated with the laneway should follow the crest more closely.

5. **Fences down slope**

   These should be at right angles to the true contour and placed so they will not collect run-off which could cause gullying.

6. **Gateways**

   These can create an erosion hazard. Generally this is minimised if gates are placed on relatively high dry ground. Deep sandy areas should also be avoided. They should not be sited in the centres of depressions or at the discharge end of contour banks.

Paddock Size

Consider:

1. Size of property.
2. Land use - farm enterprises.
3. Land Management Units.

No ideal paddock size can be prescribed. Paddock size is a compromise between large paddocks for cropping and smaller paddocks for grazing.
Optimum paddock size varies with the size of the farm, the variety of soil types, the number of land management units with different hazards of use, and with the number and classes of stock.

For the most part farmers favour a paddock size which allows them to run mobs of stock which can be conveniently handled in a day for the normal run of management practices that have to be performed. This allows for the stock to be brought to the yards, the operation performed and the stock returned to the paddock before night fall. Thus where a set stocking policy is followed if, a farmer can handle a mob of 300+ ewes and their lambs through his yards in a day at marking time, and his normal stocking rate is seven ewes to the hectare then his ewe paddock needs to be around the 40 hectare mark.

If stock are rotationally grazed, smaller paddocks are required to carry mobs of the same size at higher stocking rates for shorter time.

A number of smaller paddocks are usually required close to the yards and sheds for holding rams and/or bulls, and for holding purposes at shearing time.

Smaller paddocks are also frequently required to get optimum production from land with special hazards such as deep sands or salt affected areas. Usually special techniques have to be employed and special plant species established on such areas; also grazing control has to be strict if they are to persist.

Paddock size is usually not a critical factor. Carrying capacities vary from season to season and stock rates should be adjusted to suit the feed available. Flexibility can be achieved by selling and buying stock, agisting or hand feeding.

Water Supplies

Water supplies to all paddocks are essential both for good stock and pasture management and also for keeping erosion to a minimum.

Stock that have to travel through gateways to water bare the ground and create stock pads which tend to collect water. Much used gateways become focal points for both water and wind erosion.

Even within a paddock the position of the watering points can be important in the minimising of erosion. The ideal position for a water point is central to the paddock situated high up so that stock pads radiating from it tend to disperse run-off water rather than concentrating it.

However, other factors come into the picture not the least of which is the availability of dam sites and the cost of reticulation.

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LANEWAYS - Brian Lloyd

Laneways are more than just tracks around the farm - they should be a well designed system for conveying machinery and stock within the farm. It is an integral part of an efficient farming system.

Benefits of a well designed laneway system

Time savings - All weather access, for machinery and stock movement within the farm will save time. Much time can be lost going "the long way" via a shire road, on getting machinery out of a bog.

Labour saving - less gate opening and closing, fewer "boxed-up" sheep and sheep finding their own way back to the paddock all amount to significant labour savings.

Firebreaks- a well maintained laneway can act as a strategic firebreak.

Stock Protection area - stock may be able to be moved into a laneway system for protection from a fire.

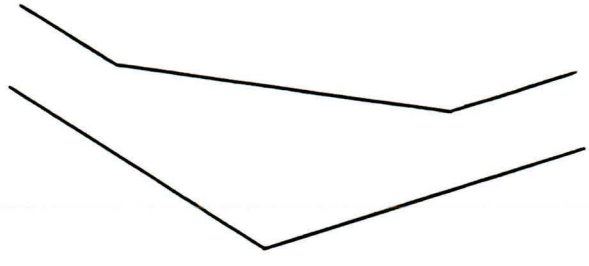
Windbreaks - laneways containing carefully selected tree species will have a positive windbreak effect on surrounding paddocks especially if the laneway is sited on a strategic ridge.

Shelterbelt - laneways with suitable trees planted can also provide shelter within, in cases of adverse weather conditions.

"Long paddock concept" - It is a misconception to think of laneways as "lost land". They should be looked upon as long paddocks that still need strategic grazing and management.

Wide corners - where a laneway has a bend in it, the inside area of the corner can be accentuated to create a working area on the laneway. This centrally located area as shown below can be particularly useful on well drained ridges especially for:

- hay storage areas
- portable yards for stock operations.



Laneway Design Points

* Follow ridges - usually ridges are good all weather access and make very effective windbreaks if planted with upper and lower storey trees. Avoid deep sands and very rocky ground.

* To get to a valley floor, follow a spur down off a ridge or go straight down the slope. Following a spur gives good drainage. Alternatively a laneway going 90^{o} to the contour will collect minimal water, whereas a laneway across a slope may collect water and cause erosion.

* If it is too steep to go straight down a slope, go across the slope on a surveyed grade line (10cm in 20 metres) leading to a safe disposal point, or follow the downside of a well-constructed grade bank. When fencing the laneway allow plenty of room for the grader to maintain the grade bank.

* Construct small spur drains along a sloping track, disposing into a grade bank or stable pasture. Laneways can help improve dam catchments in the right situations.

* Plan for a wide laneway of at least 20 metres. Allow for stock, vehicles, machinery, trees etc.

* Avoid clearing timber and pulling out tree roots. Go around vegetation stands and if a tree needs to be removed, use a chain saw to cut it off at ground level and let the roots rot. This is particularly important at creek crossings where pulling out a stump will destabilise a creek bank and cause erosion.

* Form laneways up with a slight crown to shed water but avoid major soil disturbances. Don't get carried away - you're not building the Albany Highway!

* Avoid steep grades prone to slipping, washing, gullies etc.

* Avoid gully and creek crossings. If necessary, plan for a proper crossing (culvert, floodway etc).

* Avoid siting laneways next to waterways, especially if they flood. If necessary, form a levee up on the creek side to contain water.

REMEMBER: Repair all erosion promptly and prevent future occurrences. Prevention really is better than cure.

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PERMANENT PASTURE AND CROPPING - Ashley Prout

Permanent pasture should be established on all land unsuitable for cultivation. This land can be salt affected, rocky, deep sand or land that is subject to flooding or is inaccessible during most of the year. Land that has a high erosion risk should be left as pasture.

Perennial as well as annual pastures could be considered and managed accordingly to maintain plant density, plant balance and productivity. The selection of pasture species will depend on the type of land e.g. on deep sand serradella, veldt grass should be considered, on summer moist areas strawberry clover, balansa, phalaris, etc. may be suitable whereas on good quality land that may be too steep or too rocky, a mixture of perennial grasses and annual clover would be suitable.

Areas to be under pasture permanently should be fenced separately from land suitable for cultivation so that they can be grazed when the other land is being cropped.

Perennial pastures will use more water than annual pastures and could be considered for establishing on "recharge areas."

Management of perennial pastures is different to that required for annual pastures and possibly paddocks where it is sown should be smaller than average to allow better management.

Cropping Rotation - Crop Types

Good quality land can be cropped more intensively than poor land. Land in which interceptor drains can be installed would usually be a good cropping proposition because the drains would force contour cultivation.

Generally where waterlogged or saline flats are present more intense cropping of the upper slopes tends to reduce lower waterlogging. A more intense cropping cycle usually means that attention will have to be given to crop types and the particular succession of crops needed to reduce disease and reduce the need for bag nitrogen fertiliser.

For example, lupins should follow barley or oats. Barley could be sown after lupins. After pasture (depending on grass content) oats could be sown. A typical rotation may be pasture, oats, lupins then barley. This rotation should eliminate disease and provide nitrogen for the barley crop. In this case lupins are used as a "cleaning crop" and a source of nitrogen for the following barley crop. For the "medium" rainfall eastern districts, replace oats with barley, and barley with wheat.

Rotations can be made more or less intense and can be used to renovate pasture. Intense rotations should eliminate weeds (and clover) and enable more productive varieties to be established. Less intense rotations should reduce grass content in very grassy pastures.

Canola is an excellent cleaning crop - it reduces the level of "take all" for a following barley or wheat crop, however nitrogen fertilizer is needed for a decent crop.

Crops and the various rotations can be used to increase production on the farm - both from a cash point of view and as a means of improving pasture production. By increasing cropping for example forces an increase in winter/spring stocking rate which may reduce the grass and weed percentage in the pasture for the following year.

Tillage Methods

Cultivation of any type destroys soil structure. The less cultivation the better. Minimum tillage techniques are particularly suited to this area because of the climate and the difficulty in killing weeds. On the soil types in this region, minimum tillage techniques (after a few years) usually produce higher yields than those from conventionally cultivated paddocks.

Other benefits from minimum tillage includes the ability to seed at the correct time, more sheep feed, less fuel used etc. or a greater area prepared and seeded with the same fuel in the same time.

Deep ripping may pay in some cases - trial evidence to date indicates that this may be economically worthwhile where crops are grown on sandy soils with at least 30 cms to clay.

Fertiliser Use

The use of reliable soil and tissue tests can not be stressed enough. Soil testing takes the guess work out of calculating super rates. Even people on tight budgets (like we all are) would benefit greatly by knowing where and how much super is needed. Even if your super order is not increased great benefit may be obtained by reducing rates in some areas and increasing it in others - on very old well supered paddocks super rates may be cut or super left off while high rates are applied somewhere else.

Good fertiliser use is essential to maintaining adequate plant cover and preventing erosion. Superphosphate cannot be replaced by gypsum, lime or any other witches brew - phosphorous is an essential element for plant growth.

Potassium and nitrogen are also essential major elements and can be easily determined by soil test. Production and fertiliser requirement can easily be matched to soil tests on

phosphorous and potassium. Nitrogen soil tests can not be easily related to fertiliser requirement at this stage.

Trace element deficiencies are becoming more frequent in older areas. Such elements as copper and zinc deficiencies are showing up - both these severely limit crop and pasture production.

Trace element levels cannot be related to fertiliser requirement when measured in soil samples - tissue analysis is the only accurate and reliable way of determining the requirement of these elements.

Soil acidity, a potentially major form of land degradation can also be confirmed with the use of a soil test kit. Refer to the farmnote in the 'Soil Management' section.

A soil test kit costs about the same as 300 kgs of super and it doesn't take much to return a profit on that sort of expenditure.

Superphosphate application directly governs the amount of feed produced, the amount of clover in the paddock - the amount of wool cut etc. The previous clover history and hence nitrogen levels govern the amount of grain produced by a crop etc.

In the farm plan - soil types requiring different fertiliser types should be separated. Deep sands needing potash should never be in the same paddock as gravels etc because the most suitable fertiliser would not be applied to both and production would suffer.

Pasture Species for Land Management Units

The selection of pasture species should be related to fertility and moisture status of the soil type e.g. serrradella on deep dry sand, Trikkala or balansa on wet flats, puccinellia on winter wet summer dry salt land, Paspalum vaginatum or tall wheat grass on summer moist land, Dalkeith sub clover on drier hills, etc.

Seek advice on what is most suitable to your particular situation.

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LAND DEGRADATION HAZARD AND LAND USE - Ashley Prout

Land Degradation

Land degradation is a loss of desirable soil properties causing a decline in production. Land degradation is caused by such agents as water, wind and salt. However, different types of land will be affected to varying degrees and land use and management will accelerate the process. It is of concern, because it means a loss of income, which initially is often small but in the long term may be substantial. The aim when planning your farm is to recognise which areas have the greatest risk, then choose the most appropriate land use and management to maintain on-site productivity.

The main types of land degradation in our region are soil erosion, salinisation, waterlogging, wind erosion and soil structure decline.

Identifying Land at Risk

If the most likely hazard in your area is water erosion you need to consider the soil type, and length and steepness of slope. Generally, sandy soils are more susceptible to water erosion than clay soils. But sandy soils have higher infiltration rates which tends to reduce run-off and limits erosion. Erosion is more likely on steep land or below long slopes where water may be flowing rapidly. Water erosion may also occur on flat land where drainage lines are not well defined, especially when cropped. Wind erosion is caused by climate, lack of ground cover and soil stability. Climate will be constant over the whole farm.

Infertile soils may not support adequate ground cover. Similarly soils which easily break into sand size particles will also be more likely to erode than soils which consists of large aggregates.

Salinisation may occur on land, wherever natural salts occur deep below the surface. If the amount of water escaping below the root zone is increased through land clearing and if the right hydrological conditions exist, then salts will be forced to the surface. It is not always easy to identify where salting may occur. For further information refer to the following section on salinity.

Land prone to waterlogging will occur where there is a sharp increase in soil texture, such as sand over clay, and the slopes are slightly inclined to flat. Particularly at risk are soils with blue to grey coloured clay sub soils or mottled clay sub soils. The risk of waterlogging on these soils will be increased by clearing. Soils which are most likely to lose their structure (ability to aggregate) are the heavier soils. Soil structure is destroyed by repeated cultivation and traffic and may return under pasture. Aspects of waterlogging and soil structure problems are discussed in later sections of this manual.

Land Use and Management

Once the risk associated with each type of land has been identified, the land use and management of land should then be considered. Soils which may have a high risk to soil erosion under cropping may have little or no risk with pasture. Alternatively, land may have a high erosion risk under cropping, but with different techniques and possibly more time in management, the risk may be significantly reduced. Group these different types of land into land management units may prove that it is possible to fence them as a paddock of suitable size. This can then be managed according to its hazard.

	SYMPTOM	COMMON OCCURRENCE	CONTRIBUTORY FACTORS	SUGGESTED LAND-USE	SPECIAL PRACTICES
WATER EROSION	Sheet Erosion	On sloping ground in broadacre situation. 1. On soils that shed water freely and/or have impeded drainage OR 2. Are subject to run-off from areas that shed water freely further up slope such as: breakaways,rocky laterite, mallet hills, clay patches.	Frequent cropping. Excessive cultivation for weed control. Cultivation on the "square". Overgrazing of pasture. Low super rates. Clearing of freely water shedding ground.	Livestock production based on well fertilized legume pasture OR mixed crop/livestock farming with long rotations.	Contour cultivation. Contour banks discharging into stable pastured water-ways. Run-on water inter-cepted by large size contour banks discharging into pastured waterway.
	Rill or gullies	In localised areas 1. In natural depressions	Cultivation	Retain under pasture	Fill and protect gullies mechanically & repasture
		2. Below seepage areas	Cultivation	Retain under pasture	Intercept seepage with contour drain, cut into clay.
		3. Adjacent to or along: a) Roads and tracks	Poor siting and/or maintenance		Re-site if necessary. Form up and construct spur drains at frequent intervals.
		b) Corner workings	Cultivation on the square		Work corners out first, use tyred implement work on contours.
		c) Stock pads	Too few watering points or, sited at low point in paddock. High stock rates.		Provide more watering points - one per paddock Site watering points high in paddock. Reduce stocking rate.
		d) Firebreaks	Built with plough - no loops		Use scarifier and make loops in workings. Use chemical firebreaks.
SOIL STRUC-TURE DETER-IORATION	Seed bed prep-aration difficult; sticky when wet, hardsett-ing when dry.	Heavy clays on flat or gently sloping ground.	Excessive cultivation	Livestock production based on ryegrass and/or medics. Cultivate for pasture regen-eration only.	Increase soil organic matter. Gypsum, if responsive.

	SYMPTOM	COMMON OCCURRENCE	CONTRIBUTORY FACTORS	SUGGESTED LAND-USE	SPECIAL PRACTICES
WIND EROSION	Dust storms, sand drift. Crop and/or pasture damage by sandblast.	In broadacre situation in flat or sloping country.	Lack of cover caused by 1. High stocking rates 2. Poor pasture 3. Cultivation -fallowing 4. Cropping to susceptible crops. 5. Clover harvesting	Livestock production based on pastures grazed well below crash point	a) Reduce stock rate. b) Defer grazing at opening of season. c) Reseed and/or supply adequate super. d) Don't crop, or if cropped, avoid oil seed crops. e) Don't clover harvest.
	Scald patches.	Heavy soils on ridges	Removal of native vegetation and/or frequent cropping. Salt and water erosion are often found in association.		Don't clear. If cleared, cultivate on contour, use chisel plough.
FLOODING & WATER-LOGGING	Generalised flooding	Wide flat valley bottoms with ill defined drainage lines.	Clearing in catchment with little or no compensation conservation practices.	Permanent grazing of pasture - cultivation for pasture renovation only.	Leveed waterways to contain water.
	Localised flooding	Local depressions e.g. crab holes	Silting up of drainage lines. Man-made structures such as roads.	If drainage is possible, cropping can be permitted in rotation.	W-drains
	Waterlogging - cropping and/ or pasture yellowing, stunted growth, bare patches.	On soils with restricted drain-age often at slope break.	Poor soil structure caused by frequent cropping. Run-off from higher ground. Erosion.	Cropping to oats in long rotations.	W or contour type inter-ceptor drains may be of help in some situations. Prevent run-off from above.
	Seepage areas (sometimes salty)	Localised areas where water percolating down slope strikes impervious barrier.		If salty fence and plant to to Paspalum Vaginatum if not in a drainage line.	Intercept by sub-surface drains possible but expensive.
	Land slips	Steep slopes in high rainfall	Clearing of timber.	Timber production.	Re-afforest.

Note: Other forms of land degradation occuring from salt encroachment, rocky outcrops, deep sands, steep slopes etc should be dealt with as land management units where possible.

DRAINAGE TO CONTROL WATERLOGGING - Kevin Shanhun

Problems of Waterlogging

On some paddocks, because of bogging, some farmers may not be able to sow a crop, though direct drilling may lessen the problem. The crop may then not germinate properly. They may have to sow earlier than usual to avoid waterlogging during germination, or delay seeding, which results in decreased yields because of a shortened growing period. Areas of poor or uneven seed germination may have to be re-sown. Soil structure can also be destroyed, particularly when heavy textured soils are worked when they are too wet.

In waterlogged paddocks weed control may be poor because of inadequate ground based spraying, or there may be a need for costly aerial spraying. With some herbicides, weeds must be actively growing for the chemical to be effective. Where the chemical is absorbed through the roots, weed control is less effective under waterlogged conditions.

Crops in mildly saline areas may be lost because plants usually tolerate mild salinity or mild waterlogging, but rapidly fail if both are present.

Other Disadvantages

- Saturated soils heat slowly therefore limiting crop yields and production.
- Boggy areas prevent access for farm machinery/livestock.
- Restricts aeration due to flooding, forcing out soil air.
- Leaching can occur in soils that are very porous, thus reducing the availability of nutrients for maintaining good plant growth e.g. potassium, nitrogen.
- With poor aeration, root respiration is affected, and thus with a low oxygen supply in the soil, anaerobic bacterial activity produces compounds such as sulphides which are toxic to plants.

Advantages of Drainage to Control Waterlogging

In general, the most effective method of drainage control of waterlogged areas is the one that takes advantage of the most permeable materials in the profile for intercepting, collecting and discharging excess waters from the land. One common drain currently being used in the higher rainfall areas is the interceptor drain, which is cut into the sub surface clay layer some 15 cm to intercept water moving along the less permeable clay barrier.

Other Advantages of Drainage

- Properly drained soils warm earlier in the spring, thus permitting crops to be planted early enough to mature. It takes five times the heat to raise the temperature of water one degree as is required for dry soil.
- Drainage makes the entire paddock more uniform in soil moisture.
- Drainage increases the amount of oxygen in the soil.
- Drainage decreases the loss of nitrogen from the soil by denitrification.
- Drainage increases the crude protein content in plants, along with the increased percentage of potassium, chlorine and magnesium within the plants.
- Drainage improves soil structure - the increase in wetting and drying, and the greater root growth, earthworm activity, and accelerated growth of bacteria and fungi aid in creating desirable soil structure. Deeper penetration of plant roots allow for an increase in the amount of nutrients available for growing plants, resulting in greater crop/yield.
- Drained soils reduce persistance of cereal root rot diseases.
- Drainage ensures the land is worked on the contour - decreasing the risk of erosion.

Things to Consider Before Attempting Drainage on Waterlogged Sites

* Do not divert water away from recognizable "natural" flow lines if this could cause damage to a neighbour's land or a public utility. If water is diverted to fill a dam or to allow gully reclamation, the overflow must be returned to its original natural watercourse before it leaves the farm.
* Do not allow surplus water to leave the property except in the watercourse it would have been in if there had been no contouring. A contour bank system may divert water from several minor flow lines to one definite watercourse or artificial waterway. If a return to the original course is not practical, the contouring should NOT be done without written approval from neighbours or authorities who may be affected.
* Do design, build and maintain bank systems to standards which will minimise the possibility of a failure. A broken contour bank could discharge water at the break and cause damage to roads or neighbouring land.

* Do not divert water on to road verges or other public utilities unless specific written permission has been obtained. (It is a criminal offence to divert water on to a railway line reserve.)

* Do approach road-making or other public authorities reasonably, if they divert water so that it could damage your land, to come to some arrangement or to modify their works. Remember that usually they have only narrow strips or limited space in which to protect the facilities they are providing for the public.

* Is there a safe waterway for disposal of excess water? - In some cases it may be necessary to prepare a waterway at least one year prior to being able to discharge contour drains onto them, so as to ensure a good, stable, grass covered area for safe disposal.

For further information on legalities of drainage, consult the "Saltland Management" section of this manual.

Identify Problem Areas

Considerable time can be saved when the time comes for surveying interceptor drains and W-drains if waterlogged areas have been positively identified and pegged. In paddocks that have been recently cropped and harvested, the effects of waterlogged areas can be identified by poor stubble colour, thin weak stems and a significant increase in weed (dock, grass) competition.

Finally, consider draining depressions that frequently occur higher in the landscape. These depressions may well be acting as recharge areas and therefore contributing to waterlogging of areas further downslope.

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WATER DISPOSAL AREAS
- David Stanton

The most important aspect of soil conservation design is the provision of adequate disposal areas or waterways for run-off water. Run-off from sloping ground must be moved in a controlled manner that will not result in gully formation. Uncontrolled run-off is concentrated by natural topography. Controlled run-off is concentrated to disposal areas by contour banks. Large amounts of energy are dissipated as water flow moves downslope. A flow of 1.4 m3/s. for the 30 m down a 5% slope release energy at a rate of more than 20,000 watts. For large run-off volumes it may be necessary to supplement the grassed waterway with gully control structures.

The capacity of the waterway should be based on the estimated run-off from the catchment. Design should be for the highest daily rainfall for at least a 10 year return period.

Waterways

Stable waterways are essential to the safe disposal of run-off water from agricultural land. They provide a means for run-off water to flow to a lower level in the landscape without causing water erosion.

Waterways can be in either natural or constructed. Natural waterways follow existing drainage lines and retain the flow of water with their own natural shape, that is without levees or retaining banks. Artificial waterways are constructed with a channel capacity and shape designed to convey the predicted flow of run-off water.

Artificial Waterways

These can be either:-

A stable natural depression confined by earthworks constructed to increase its capacity.

An area of evenly sloping land allowing for the entry of flow from grade banks on either side.

Design of these systems should be carried out by a suitably qualified person who will take into account the size of the catchment, peak flow, legalities etc.

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ORIGINS, TYPES AND MANAGEMENT OF SALINITY - Brian Lloyd

ORIGINS OF SALT

The majority of salt in the south west land division of W.A. originates from the ocean and is deposited inland mainly via rainfall. Near the coast, dust and spray also contribute. It is called cyclic salt.

Quantities of salt received include:

	Kg/ha/yr
Perth	341
Kojonup	67
Merredin	18

Analysis of rocks in the S.W. land division indicate that there is far more salt in the landscape than can be accounted for by rock weathering. Ancient sea bed weathering is of more influence in parts of the Eastern States and the U.S.A.

The earliest reference in W.A. to salinity due to vegetation removal was in Northam-Toodyay in 1897. In 1902 parts of Mundaring reservoir catchment turned saline after some clearing, as did some railway reservoir catchments around 1917. In 1924, Wood proposed the cyclical salt theory of ocean- originating salt being deposited inland via rainfall and being stored in the soil. Removal of deeper rooted vegetation allowed more water to enter the groundwater table and cause it to rise bringing salts to the surface. This theory basically holds true today.

Brief Geology

The basement rock under most of the S.W. land division belongs to the Yilgarn Block. This is an extremely old and weathered landscape over 2,500 million years old.

Originally it was a stable region of granite rock, however over millions of years it has intensely weathered, often to a depth of 30 metres. This profile has then been heavily leached.

This leaching lead to a change in structure, with new material taking up as little as 60% of the original material. This new porous pallid zone on top of the granite was capable of storing huge qualities of salt over millions of years (up to 1,000 tonne/ha). Unfortunately this newer material also has a low hydraulic conductivity or a low ability to pass water, and so collected its salt load. With the removal of deeper rooted vegetation more rainfall infiltrated deeper into the soil, mobilising the salt to lower parts of the landscape.
The lower rainfall areas tend to store more salt in their landscapes due to the poorer drainage and flushing effects experienced in these areas of lower relief. Areas nearer the coast have a more rejuvenated drainage pattern, and can more readily channel rainfall into well defined systems and back to the ocean.

TYPES OF SALTLAND

Primary salinity is that which is naturally occurring e.g. salt lakes.

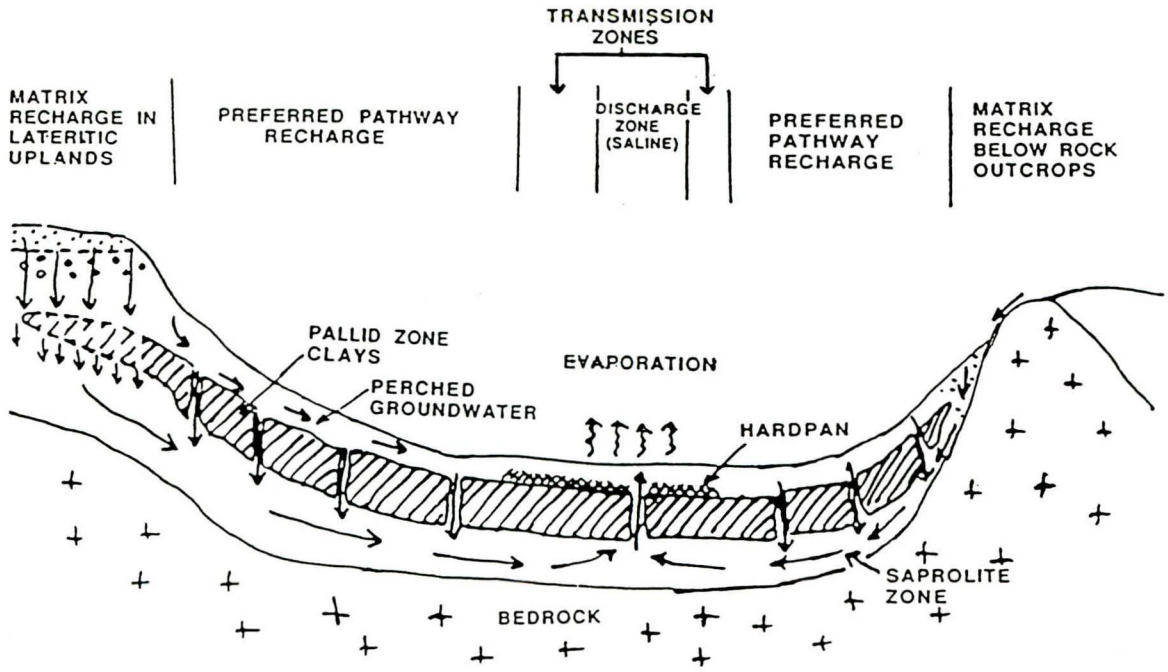
Secondary salinity is that which has occurred in relatively recent times on previously productive land. With regard to secondary salinity, the two main forms that affect this region are:

- valley waterlogging
- hillside seepages.

1. Valley Waterlogging

This is the most extensive form of secondary salinity in the south-west land division. It occurs when deep rooted native vegetation is replaced by annual crops and pastures. There is then increased water infiltration through the profile (or recharge) mobilising stored salts and exporting them to sites lower in the landscape. Water movement out of the system is slower than water movement into the system (i.e. rainfall) and saline groundwater levels rise in the lower areas. When the saline groundwater comes within 1.8 metres of the ground surface, the sun is able to draw up the saline water to the surface, evaporating water and leaving salt concentrates behind. This is called capillary rise. (see diagram)

This problem is further exacerbated when poor surface drainage leads to surface ponding. Plants which can tolerate minor amounts of salt or waterlogging cannot tolerate both combined, and they die. These bare areas then increase the rate of capillary rise further compounding the problem.



Landscape Cross-section of Valley Waterlogging Salinity

2. Hillside Seepages (Courtesy: Dr Bob Nulsen)

"Hillside seepage" is a local, descriptive term applied to almost any wet patch occurring out of the valley bottom. Depending on their surface appearance "hillside seepages" are described as "springs", "soaks", "wet patches" etc. A Canadian hydrologist has termed such occurrences as "groundwater outcrops" which is a bit of a mouthful and American hydrologists prefer the simple term "seeps".

Whatever you decide to call them - and I prefer the simple "seep" - they can cause problems. Not only is the land in the seep wet, unworkable and non-productive but if the seep is saline and the water flows downhill, further land is lost from production, bared and subject to erosion. Even small seeps, while not affecting much land, break up a paddock and complicate the working pattern for tillage and harvest.

Definition of terms:

To understand the causes of seeps it is necessary to define some terms used in describing water flow through soils.

Hydraulic conductivity is a measure of capacity of a soil to transmit water under unit hydraulic gradient. Since we are mostly concerned with groundwater the relevant measure is the **saturated hydraulic conductivity.**

Hydraulic gradient is the gradient, or slope between the pressure of water measured in two different parts of the soil. Water moves down the hydraulic gradient from an area of high pressure to an area of low pressure.

Flow velocity of water through a soil is the product of the hydraulic conductivity times the hydraulic gradient.

Causes:

Seeps occur when water is forced towards the soil surface. When the water comes to within 1.5 to 2 metres of the surface the first signs of a potential seep appear - plants will stay greener longer in spring and early summer and the soil surface will be damper. With time and the right conditions free water will eventually seep out of the surface and may run a considerable distance down hill.

Seeps can be either fresh or saline. Fresh seeps are often developed as soaks for stock water supplies. The amount of salt in seepage water depends on the origins of the water.

In general, if the water has travelled through the deeper layers of the soil profile, which have a high salt storage, the seep will be saline. Seeps which are fed by shallow flowing water, or water that has come through sandy soil, tend to be relatively fresh. The salinity of the seepage water gives a clue as to its origin and to what is causing the seep.

There are four main landscape structures which cause seeps in southern Western Australia.

1. **Bedrock high seeps** (Figure 1) result when the bedrock comes close to the soil surface. Groundwater moving downslope is impounded behind the bedrock high and forced towards the soil surface. The bedrock high is occasionally visible on the surface as a "rock bar."

   These seeps are usually saline, not associated with a change in soil texture and might be improved with drainage immediately above or in the seep.

2. **Dyke or texture change seeps** (Figure 2) occur when soil of lower hydraulic conductivity cuts across a slope. The low conductivity soil may be the result of weathering of a dyke. The seeps are usually saline and associated with a texture change. However if the dyke cuts across a deep sand the seeps can be fresh.

   Dykes sometimes outcrop on the soil surface laterally upslope from the seep. Dykes are also detectable by using a magnetometer which is a common geophysical instrument. There are consultant geophysicists experienced in detecting dykes.

   These seeps can often be improved by deep drainage upslope of the dyke and there are experiments under way examining the possibilities of cutting through the dykes.

3. **Seeps at the base of sands** (Figure 3) occur at the downslope junction of deep sandy soils and fine textured soils such as clays and clay loam. Water perches in the sand on the clay and moves downslope coming out at the base of the "sandhill". These seeps are usually fresh since sandy soils store very little salt. However, if there is a contribution to the seepage water of water coming from the clayey soils, the seeps can be saline.

   These seeps, if relatively fresh, can be developed for stock water supplies. If they are saline a drain at the base of the sandy rise can be used to safely dispose of the saline water and thus prevent it from flowing over fresh soils down slope.

4. **Seeps at the change of slope** (Figure 4) occur because there is a reduction in hydraulic gradient downslope. As a consequence the soils downslope can't transport the water being fed from upslope and water builds up at the break of slope. These seeps are usually saline, not associated with a soil textural change and are characterised by a concave slope (see Figure 5). While deep drainage at, or above, the seep may be effective, it will be necessary to treat the recharge area feeding the seep.

Farmnote
No. 3/89
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Agdex 534
Soil acidity

Management of topsoil acidity in cropland

By Michael Lamond, Adviser and Perry Dolling, Research Officer, Northam and Bill Porter, Research Officer, Merredin

Many light textured soils in the State's cropping areas were slightly acid before they were cleared. With the introduction of agriculture these soils are becoming more acid because of

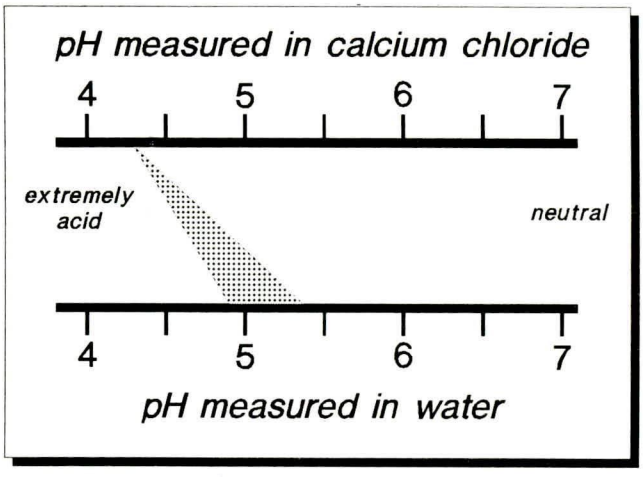
- leaching of nitrogen out of the root zone; and
- removal of produce (grain, seed, grazing) from the paddock.

Lime can be applied to acid soils to raise the pH of topsoil. In Western Australia, measurable increases in pasture growth and cereal grain yield from liming have been shown on soils with a low pH. There are two main points to consider when applying lime.

- Know the pH of the soil before spreading lime.
- When buying lime, compare different sources and types of lime and take into account the price, its neutralizing value and particle size.

Leaching of nitrogen will cause acidification, irrespective of whether the nitrogen came from growing legumes or was applied as fertilizer. All the nitrogen in Agras, sulphate of ammonia and DAP is ammonium and this form is the most acidifying of nitrogenous fertilizers. Fertilizers which increase the growth of legumes, for example, superphosphate, will increase the acidification rate of the soil. Superphosphate itself does not directly decrease the pH.

Removing produce from the paddock can be thought of as being equivalent to removing lime, leaving the soil more acid. Hay with a high legume component 'contains' most lime-equivalents (about 40 to 80 kilograms lime per tonne of hay), cereal hay 'contains' less (about 15 to 20 kilograms lime per tonne hay) while cereal grain contains even less (about 2 to 4 kilograms lime per tonne grain).



A soil with a pH (calcium chloride) of 4.3 - indicating problems for sub clover - may have a pH (water) of 4.9 or lower, or a pH (water) of 5.3 or higher.

Figure 1. *pH (calcium chloride) is a more reliable indicator of soil acidity than pH (water)*

Soil pH test in calcium chloride

Soil pH is a measure of how acid the soil is: the lower the pH, the higher the acidity. Soil pH can be measured either in water (the method used by CSBP & Farmers) or in calcium chloride ($CaCl_2$). The calcium chloride method is a more reliable measure of soil acidity. The pH ($CaCl_2$) is usually lower than the pH (water). The difference is often about 0.6 to 0.8 units, but can range from zero to two units (see Figure 1).

Applying lime to soils will not result in economic production increases until the soil pH approaches low levels. It is important to know the pH of the soils in order to know whether your level of production is at risk from acidity. You can then make decisions about liming paddocks.

Crop and pasture tolerance to low pH

Low pH affects rhizobium survival and nodulation of leguminous pastures. For cereal crops, low soil pH causes aluminium toxicity which is the major cause of yield loss.

A 'critical soil pH range' can be defined as in Figure 2. While the pH is above the critical range, plant growth will not be affected by soil acidity. The risk of plant production losses of 20 to 30 per cent increases from low to high as the pH drops from the top end (high pH) to the bottom end (low pH) of the critical range. Soil pH values below the critical range indicate a very high risk of severe plant growth problems because of soil acidity.

The critical pH ranges for crops and pastures are shown in Figure 3. In the cropping areas, sub. clover pastures generally will not give a response to lime unless the pH ($CaCl_2$) is about 4.3 or less.

To avoid future production losses of sub. clover pastures, apply lime if the soil is at or below pH ($CaCl_2$) 4.5 as the soils acidify over time.

Some plants are more tolerant to low pH than others. An alternative to applying lime to an acid soil is to plant more acid tolerant species.

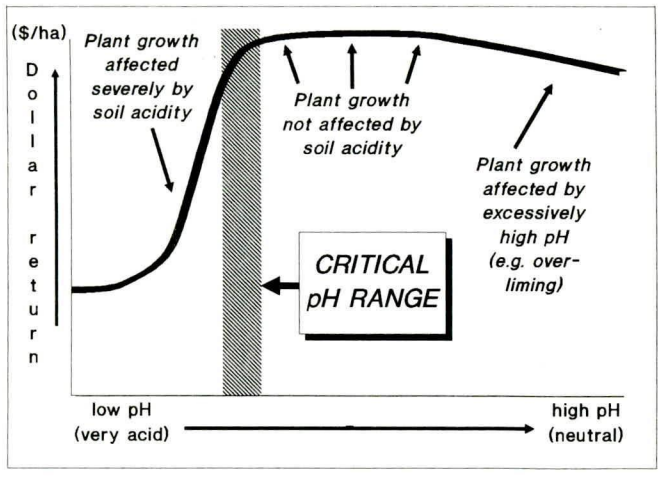


Figure 2. *A critical soil pH range can be defined for plants*

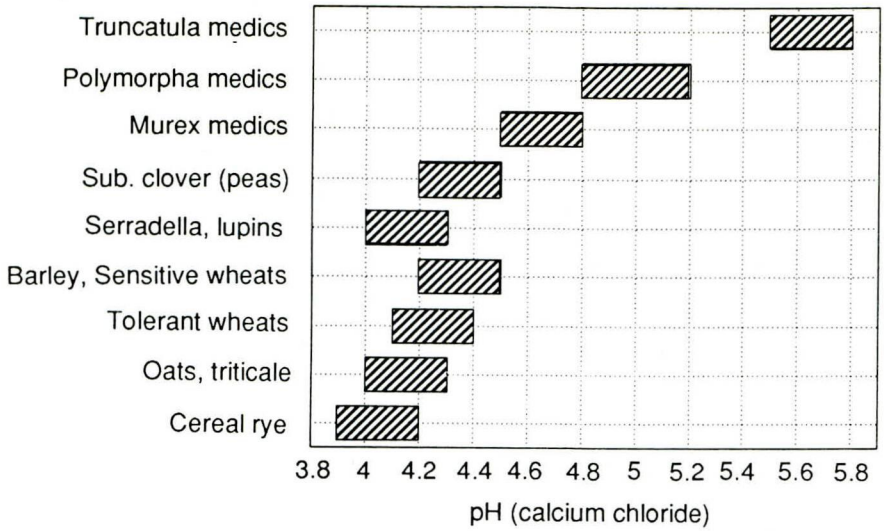


Figure 3. Critical topsoil pH ranges for crops and pastures

Types and sources of agricultural lime

There are three main types of lime available in Western Australia for agricultural purposes.

- lime sand
- crushed limestone
- burnt lime

Particles of lime smaller than 0.6 mm diameter will react within the first year after being cultivated into the soil. Particles larger than 1 mm diameter will not react for more than 5 years. Particles larger than 2 mm have little benefit.

All lime registered for agricultural use is given a neutralizing value. This gives an indication of how effective the lime will be in raising the pH of the soil. Table 1 shows how to compare lime sources. In the worked example the lime which appears cheaper ($5.00/t compared with $7.00/t) is actually a more expensive source of 'pure lime equivalent' on-farm ($31.25/t compared with $28.42/t) because of its lower neutralizing value (80 per cent compared with 95 per cent).

Application of lime

On the sandy textured soils of the cropping areas, lime at 1 t/ha with a neutralizing value of about 90 per cent will increase the soil pH by about 0.3 to 0.5 of a unit. It is not known how often lime will need to be re-applied.

Lime can be applied as one application of 1 t/ha or in smaller, maintenance levels more frequently. Too much lime can induce trace element deficiencies. To avoid production losses do not apply lime to high pH soils or use high rates of lime (greater than 2 t/ha).

Lime can be spread any time of the year, but avoid situations where it may be subject to wind erosion. It is best applied before a cereal crop, rather than lupins or a pasture.

Lime must be well mixed with the soil before it neutralizes it. Cultivation before seeding rather than direct drilling will give best results.

Applying lime may also increase the availability of nitrogen to cereal crops in that year as the pH is more suitable for microbes which break down soil nitrogen.

If re-seeding a pasture after a cereal crop that has been limed, inoculate the clover seed with a suitable rhizobia to ensure the clover will nodulate.

Lime particles are fine compared with superphosphate or urea. If left uncovered in the paddock the particles can easily blow away. As lime is fine, some of the older types of spreaders have difficulty handling it. It is important to check that your spreader is distributing lime uniformly across its width.

Further reading

- Farmnote No. 84/86 'Liming of sub. clover pastures on acid soils in the high and medium rainfall areas of W.A.' (Agdex 137/534)
- Farmnote No. 68/84 'Soil acidity' (Agdex 534)
- Journal of Agriculture, (1984) Volume 25, No. 4 . 'Soil acidity'.
- Yeates, J.S. (1988) 'Soil acidity and productivity of sub. clover pastures' *J. Agric. West. Aust.* **29**:20-2

Table 1. To compare lime sources of different neutralizing values and different prices

Cost of lime at the pit ($/t)	+	Cost of transport to the paddock ($/t)	+	Cost of spreading ($/t)	+	Neutralizing value (%)*	=	Cost of pure lime equivalent ($/t)
5.00	+	10.00	+	10.00	+	0.80	=	31.28
7.00	+	10.00	+	10.00	+	0.95	=	28.42

* Divide the neutralizing value (%) by 100.

ISSN 0726-934X

THE SOIL - ARE WE LOSING ITS STRUCTURE - Matthew Flugge

Introduction

Soils are the asset and wealth of our farms. Economic times are forcing farmers into achieving higher production from the soil, through overstocking and more intensive cereal production which may lead to degradation of the soil through erosion (wind and water), heat (the baking effect), and compaction.

The soil generates all activity on your farm and as such, it must be recognised as a number one priority.

What is Soil Structure?

The soil structure describes the arrangement of the major soil constituents: the sand, silt and clay which are bound by cementing agents, e.g. clay, organic matter, certain iron and aluminium minerals to produce soil aggregates.

The size, shape and distribution of aggregates has a big influence on the nature of the air spaces or pores within the soil.

There are three types of pores -

* **Transmission Pores (Large)**

  Characteristics:
  Larger than other pores
  Occur between aggregates
  Allow rapid movement of air and water through the soil
  Most vulnerable to degradation.

* **Storage Pores (Small)**

  Characteristics:
  Found mostly within aggregates
  Hold water against gravity
  Allow water to be extracted by plants

* **Residual Pores (Very Small)**

  Characteristics:
  Contain water generally not available to plants.

The main concern is that soil structure be stable, that is withstand effects of rainfall and mechanical manipulation. Any change from the stable soil structure can lead to plant growth limitations.

The Advantages of Good Structure

1. Increased root development

Root development of cereals and pastures is increased as the roots can move freely through well structured soil because air and water are available. In compacted soil structure, pores are almost non existent and root development is limited.

2. Increased Organic Matter

The root system of the plant dies and decomposes adding valuable organic matter to the soil at depth. This organic matter gives the soil valuable biological at life at depth.

3. Increased rain infiltration.

The rain that falls on the soil, is either absorbed downwards (infiltrates) or may run-off the soil. With a well structured soil, more rain infiltrates and there is less run-off and therefore less erosion. With better infiltration the movement of water into the soil allows easier working of the soils for cereal or pasture production. Good infiltration and aeration allows germination of pastures to commence on lower rainfall and normally earlier in the season when soil temperature permits rapid growth.

4. Improved aeration

Aeration allows gases to be exchanged between soil and the atmosphere. Transmission pores allow the oxygen through. If aeration is non existent then plants suffer, e.g. waterlogging where no oxygen is available to the plant's roots, as opposed to hydroponics where the water has been oxygenated.

5. Soil Strength

Good soil structure maintains soil strength at a level which:

- allows seedlings to emerge easily
- allows roots to grow uninhibited
- anchors roots firmly
- resists damage from erosion and rain drop impact.
- allows ease of cultivation

The above equates to improved fuel economy, less stress on equipment, better seed bed condition and more vigorous crops and pastures.

A Simple Test of Your Soil Structure

In testing your soil structure there are no hard and fast rules set down by the Department of Agriculture. As there are many soils across Western Australia, then the structure of the soil will be just as variable.

Your interpretation in evaluating the condition of your soil, is important, as you will be seeing the structure improve or deteriorate, depending on management practices.

After the break of the season and when your pastures have germinated, take a shovel or fork (preferably a garden fork as this does not slice the structure, leaving a good face to view) and dig down to the depth of the fork. If the soil is well structured the fork will sink easily, without excessive force. The next step is to examine where the bulk of the roots are present. In poorly performing pastures, 90% of roots will be congregated in the top 5-8 cms of soil and the soil structure will change at that level. Plant roots will be seen to be going sideways rather than down indicating a barrier to root development. The soil above the 5-8 cms level will be more friable than the soil below, which will be hard and more packed and difficult to break with your hands. In good pastures, the roots will extend to 15-18 cms, if not further, depending on the pasture and soil type. If this is the case the soil is well structured. Also look for worms, or signs of their presence, as they are an indicator of good soil structure and can work their way through

quite hard soils.

If your soils fall into the poorly structured soil category, then you can expect that pastures and cereals are not yielding to their potential.

To correct the soil structure problems may take several years, however it is necessary if you wish to survive, and achieve production from your property relative to the potential of your fertilizer and seed used.

Management Practices to Improve Soil Structure

Soil structure can be improved by the adoption of the following programmes:

1. Gypsum
2. Deep tillage
3. Direct drill/min tillage
   (Refer to Farmnotes in this section)

Facets of stock production and cereal production also need to be considered to help improve soil structure.

Stock production:

* Deferred stocking allows more vigorous growth of plants leading to:

  - Increased root systems
  - Decreased hard pan development
  - Increased moisture availability
  - Increased rain infiltration
  - Increased pasture production.

* Planned grazing management should be adopted on paddocks with similar units of poorly draining soil. This should ensure stock are not "pugging up" poorly drained areas in the wet, or overgrazing more favoured parts of the paddock. Here, fencing to Land Management Units should be considered.

* Deep tillage practices to remove hard pans.

Cereal Production:

Here, soil structure improvement requires cultivation at the ideal time.

If the soil is too dry - soil aggregates are smashed.
If the soil is too wet - smearing and slicing of aggregates can occur.

The speed of cultivation should be at fast walking pace (8 km/hr). Avoid cultivation which produces a throwing motion.

Summary

Your soil and soil structure need as much attention as the rest of your farming enterprise. This can be achieved by sensible management practices such as establishing good pastures (perennial or annuals), sensible stock rotations and minimum tillage operations for cereal production.

These practices need to be worked into a whole package for the farm operation to improve the soil structure for years to come.

Acknowledgements

Burton, Peter. The Gumboot Test, Growing Today October 1990.

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Farmnote
No. 32/85

Western Australian Department of Agriculture

Agdex 514

Gypsum improves soil stability

By G. Fosberry, Adviser and M. Howell, Research Officer, Dryland Research Institute, Merredin

Crop growth is often limited by the poor structure of heavy textured soils. Gypsum can improve soil structure, increasing crop yields and making soil more manageable.

Once a soil has been improved it is essential to prevent degradation re-occurring. Minimum tillage techniques play an important role in conserving the improvement.

Gypsum (calcium sulphate) is a naturally occurring mineral found commonly as dunes at the south eastern edge of salt lakes. When applied to a soil, gypsum dissolves and interacts with the clay. This interaction improves soil structure by making the clay more stable when wet and reducing the tendency to set hard when dry. In practice gypsum may:

- reduce crusting or surface sealing,
- improve crop establishment,
- aid drainage of the soil surface,
- lengthen the time the soil is suitable for cultivation, and
- prevent crops haying-off prematurely.

Gypsum is not a treatment for traffic compaction pans, non-wetting sands and soil acidity. Saline soils can be treated with gypsum but only when the soil has been drained and leached of salt.

A beneficial response from gypsum will only occur where:

- soil structure is limiting crop growth, and
- the soil is responsive to gypsum.

Recognising a gypsum-responsive soil

The Department of Agriculture has experimented with gypsum since 1965. Wheat yield improvements have been highly variable, ranging from nothing to over 450 per cent (in one case in 1983). Usually, responses ranged between 30 and 50 per cent. Most responses occurred on hard-setting grey sandy loams overlying a sandy clay, and on some red clays.

The following procedure will help you recognize a gypsum-responsive soil:

1. Take a sample of soil from the surface and another 15 cm below the surface.
2. Place about 50 mL of distilled water or freshly collected rainwater (stored rainwater and tap water may not be pure enough) into each of two clean jars. These jars should be labelled "surface" and "sub-surface" for easy identification.
3. Wet the soil sample with the distilled water to a moisture level similar to that when seeding in good conditions that is, soil should be easily manipulated but not sticky.
4. Re-mould the soil sample into a sphere (about seven millimetres in diameter) and gently drop into the appropriate labelled jar of water.
5. Leave the jars completely undisturbed for 24 hours. If, after this time, a milky cloud or halo has formed around either of the aggregates then the tested soil is likely to be gypsum responsive.
6. As soil can vary greatly even a few metres away, repeat the test with samples from different parts of the suspect area.

The test, though simple is a rough guide to responsive sites. Research into more accurate tests for gypsum responsiveness is continuing.

Gypsum test strips

If the problem soil is gypsum responsive according to the soil test, and crop yield is being depressed by the unstable structure of the soil, then test strips are warranted to assess whether gypsum application will be beneficial.

When doing test strips:

- Apply the gypsum at several rates, for example, 2.5 and 5.0 t/ha.
- It is essential to leave an untreated strip which will confirm whether there was a response to the application of gypsum and in subsequent years will enable an assessment of when re-application is necessary.
- Where no response is measured, continue observation of the strips over at least two seasons to account for seasonal variation.

Methods of gypsum application

Conventional chain-delivery superphosphate spreaders are not suitable for applying gypsum because gypsum is not a free-flowing material. However, there are several commercial spreaders which are suitable. A spreader can be bought or hired or a contractor hired to apply the gypsum.

Often, areas where gypsum is to be applied are bare. On these bare areas the gypsum should be "scratched" into the soil surface to reduce chances of it blowing away.

To be effective gypsum should be applied before the break of the season.

Application rates

In the 1984 experiments conducted by the Department of Agriculture, 2.5 t/ha gypsum gave maximum grain yields. However, for the more unstable soils and where the treated soil surface has suffered from untimely or intensive cultivation, gypsum may need to be re-applied sooner if 2.5 t/ha rather than 5 t/ha is used.

A possible strategy, following the 1984 results, would be:

- apply gypsum at 2.5 t/ha over most of the unstable soil, and
- use 5.0 t/ha on the most unstable country.

Research on the long term consequence of gypsum application: persistence, maintenance of favourable soil structure and cost effectiveness; is continuing.

Continued overleaf

Maximising gypsum effectiveness

Consideration of the following points will ensure that maximum benefit of gypsum application is obtained.

- Gypsum must dissolve in rain water before it can act on the soil. It should therefore be applied before the break of the season.
- Preventing the newly applied gypsum from blowing away is important. However, the gypsum should be kept as close to the soil surface as possible. If cultivation is necessary, do the minimum required.
- Increasing the normal rate of nitrogenous fertiliser or the application of nitrogenous fertiliser where none is normally used, should be seriously considered. Yield increases on some soils treated with gypsum have only been fully realised with additional nitrogen. Other soil types have shown minimal response to nitrogen after gypsum treatment. Use test strips of nitrogen as indicators.
- Following gypsum treatment, minimum tillage or direct drilling practices should be adopted. Minimum tillage techniques encourage a build up of organic matter at the soil surface which further improves soil structure. The improved soil conditions achieved with the gypsum and organic matter will be conserved by minimal surface disturbance, and the residual or undissolved gypsum will remain close to the soil surface. Protection of the treated surface from further degradation may make gypsum application a once-only requirement.

Persistence of the gypsum effect

A major factor in the economics of gypsum use is the persistence of favourable soil effects. Persistence will depend on many factors including:

- the rate of gypsum application—more gypsum lasts longer,
- the intensity and frequency of rainfall,
- the soil type, and
- the management practices adopted after the gypsum application (minimum tillage techniques required).

Gypsum quality

Gypsum suppliers should be able to provide a comprehensive analysis of their gypsum. However, a 500 g sample can be sent for analysis to:

Government Chemical Laboratories
30 Plain Street
EAST PERTH WA 6000
Telephone: (09) 325 5544

Ideally, the proportion of gypsum should be greater than 70 per cent. Lower percentages increase the cost of cartage and application.

The chloride or salt content is also important. Supplies which have over 1 per cent chloride, are suspect and those over 2 per cent chloride should not be used (figures from the Department of Agriculture, South Australia).

The costs of gypsum

Gypsum costs between $4 and $10 per tonne at the mine (1985 prices). The cost of gypsum per hectare is extremely variable and depends on:

- freight—this is usually the greatest cost, hence the distance from the source is important,
- the rate applied,
- purity of the gypsum used, and
- price

The table outlines the approximate costs of gypsum per hectare. The influence of gypsum quality and distance from the gypsum source is easily seen.

Examples of the costs of gypsum application

Gypsum rate (t/ha)	Distance from gypsum source (km)	Gypsum content (% calcium sulphate)	Total cost of gypsum application* ($/ha)
5.0	100	100	68.00
5.0	100	70	93.20
5.0	20	100	40.00
2.5	100	100	38.00
2.5	20	100	27.50

*Prices used: Gypsum = $5/tonne
Contract cartage = 7c/tonne/km
Contract spreading = $8/ha

NOTE: These costs can vary, especially if you use your own truck and spreader.

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Farmnote
No. 7/90
Western Australian Department of Agriculture

Identifying gypsum- responsive soils

By Fionnuala Frost, Research Officer, National Soil Conservation Program and Garry Orr, Technical Officer, Division of Resource Management, Merredin

Soils containing dispersible clays are often problem soils. A dispersible clay is a clay that does not stay stable when wetted, but slakes or disperses easily.

The major problem with dispersed clay is that it can block soil pores and reduce the permeability to water. The clay also acts as a cement that hardens the soil when it dries.

Gypsum applied to soils with dispersible clays improves the permeability to water by reducing the dispersion of the clay. Reducing the dispersion allows more of the rainfall to enter the soil, reducing run-off and erosion risks and improving drainage after heavy rains.

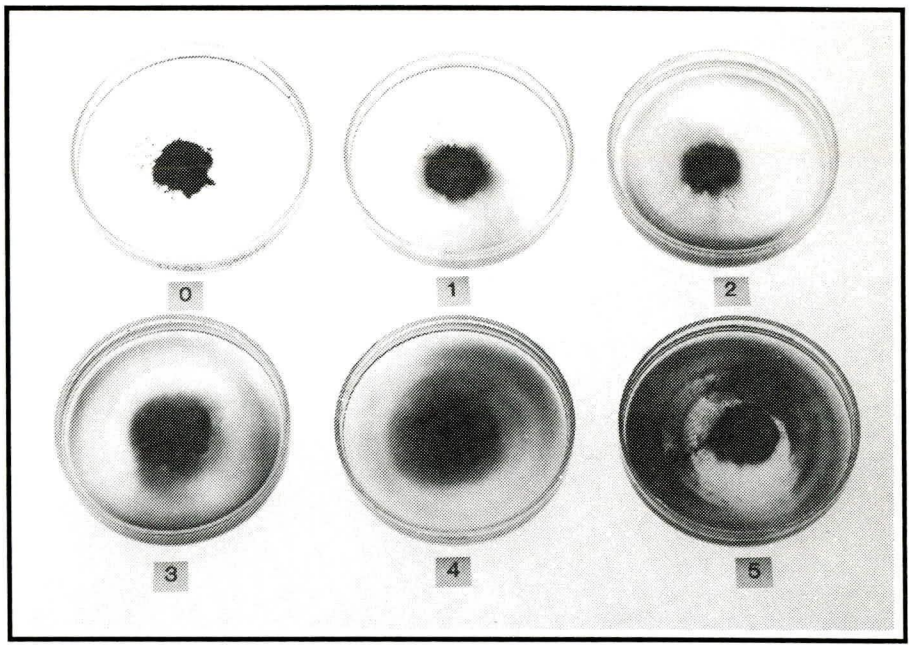


Figure 1. Varying degrees of clay dispersion in soils. The higher amounts of dispersal (4 and 5) indicate a soil's suitability for gypsum application. No. 0 displays slaking (breaking off of soil particles), compared to 1 to 5 which show clay dispersion.

The action of the dispersed clay in hardening the soil (or increasing soil strength) is also decreased by applying gypsum. The lower soil strength allows for more timely cultivation and seeding. Energy inputs and machinery maintenance can be reduced, while decreased soil strength also allows improved crop performance from rapid emergence, improved aeration and efficient water use.

The benefits from applying gypsum will vary, depending on the season. Apply gypsum with the aim of adopting more sustainable, reduced tillage, rather than continuing with multiple workings and having to reapply gypsum a few years later.

Several tests to help identify gypsum-responsive soils have been developed through research, including trials conducted by the Department of Agriculture. Testing is necessary because soils vary in chemical composition and physical properties as a result of their inherent condition and management practices imposed on them.

Two of the simplest assessments are described here. These are:

- using field observations, and
- using a simple dispersion test.

Field observations

Soils likely to be structurally degraded (lose their crumb structure when wet), and likely to be gypsum-responsive may:

- be hard when dry or have a surface crust (note that not all crusting soils are gypsum-responsive);
- become sticky or non-trafficable after light rainfall; puddles of water will have a milky appearance from the suspended clay;
- be difficult to cultivate because they are too hard or too wet;
- collapse after heavy rainfall;
- have low water infiltration and high run-off;
- produce patchy crop emergence and early growth, particularly in poor seasons.

Visual dispersion test

Apart from looking at the condition of the soil and crop, you can do a simple test on the farm to determine if your soil is likely to respond to gypsum. The dry aggregate dispersion method described below includes photographic standards for providing a scale of the degree of dispersion (see Figure 1).

The process of clay dispersion is a reliable indicator of unstable soil structure. Highly dispersive (structurally unstable) soils are likely to be more gypsum-responsive than those soils that are less dispersive.

Materials

- 100 mL beakers or 500 g glass jars (Vegemite jars are suitable)
- distilled water or fresh rainwater (scheme water is unsuitable)
- dry soil aggregates (small clods, or clumps)
- black surface (bench, cloth or paper)

Method

1. Take about ten dry soil samples from the area to be tested, half from the soil surface and half from a depth of 15 cm. Highly dispersive topsoil is far more limiting in terms of potential productivity than dispersive subsoils.

2. Label each soil sample and break the sample into aggregates, or amounts about 5 mm in diameter.

3. Pour 50 mL of distilled water into ten separate, clean containers and place on the flat, dark surface. (If you are using 500 g Vegemite jars, add 100 mL of distilled water to each. You will then be able to place five aggregates in a jar without affecting the results.) However, make sure you do not have samples of both topsoil and subsoil in the same jar.

4. Label the containers to identify each sample.

5. Gently place one aggregate into the centre of each beaker or jar and allow to stand for 24 hours without disturbance. (Make at least two tests for each sample to ensure the results are consistent.)

6. Rank the degree of dispersion on a scale from 0 to 5. Use Figure 1 to estimate this.

The results of the test are explained in Table 1.

Table 1. Likely response to gypsum of soils with varying levels of clay dispersion

Ranking	Dispersion (%)	Aggregate stability	Response to gypsum
0	0	Very high	Nil
1	20	High	Very low
2	40	Moderate	Low
3	60	Low	Moderate
4	80	Very low	High
5	100	Nil	Very high

A soil is likely to respond to gypsum if from field observations it shows the characteristics associated with poor soil structure and will readily disperse (ranking of 4 or 5).

All clays swell on wetting and the process of swelling causes particles to mechanically break off from the aggregate. This process is called slaking and is illustrated in Example 0 in Figure 1. This is a different observation to dispersion where the clay disperses to form a milky cloud around the aggregate.

It is the dispersiveness of a soil that determines its likely response to gypsum.

The recommended rate for applying gypsum is 2.5 t/ha. Test strips are recommended on the targetted paddocks in the year preceding a blanket application to observe any responses to gypsum. If there is no response, continue observing the strip for a further season to account for seasonal variation.

Some soils are non-trafficable after rainfall and yet will not be dispersive. The sign to look for in this situation is a sandy to sandy loam-surfaced soil with a massive tight clay subsoil. Waterlogging is invariably the problem on these soil types. The clay subsoil prevents surface water from draining deep into the profile. Where this happens, to minimize degradation you can take the following steps:

1. Reduce tillage.
2. Avoid working the paddock if it is saturated.
3. Reduce the volume of surface water flowing onto the paddock, for example, by installing recommended earthworks.

Further reading

- Farmnote No. 99/84 'Direct drilling on the contour to control erosion' (Agdex 572).
- Farmnote No. 32/85 'Gypsum improves soil stability' (Agdex 514).
- Journal of Agriculture (1988). 'Gypsum use in the wheatbelt'. Vol. 28, No. 2.

570/7/90—6,500 ISSN 0726-934X

Farmnote
No. 61/85
replaces No. 50/85

Western Australian Department of Agriculture

Agdex 100/21

Deep ripping

By Officers of the Department of Agriculture

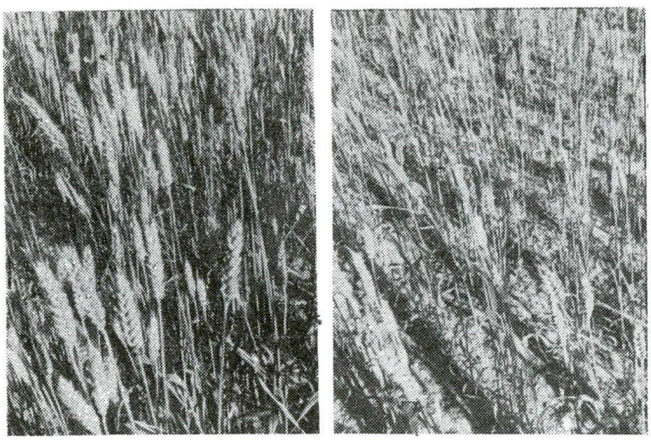
Deep ripping, to remove traffic-induced hard pans, is recommended for cereal crops on yellow loamy sands where finishing rains are reliable. Over forty experiments since 1979 have shown the benefits from deep ripping. Wheat roots are able to penetrate the ripped soil faster and deeper to absorb more soil moisture, capture more soil nutrients and improve yield.

On Wongan loamy sands and Eradu sandplain, normal cultivation produced cereal grain yields 10 per cent higher than yields from direct drilled crops (that is, 1430 kg/ha versus 1290 kg/ha). Deep ripping improved yields further. From twenty one trials over four years, the average yield increase from ripping 30 cm deep was almost 500 kg/ha (see Figure). Yields were 30 per cent higher than from plots cultivated normally. The greatest yield increase from ripping was 1,050 kg/ha and the highest percentage increase was 142 per cent. Only one trial showed a yield decrease (of 100 kg/ha or 4 per cent) from ripping.

Direct drilling and deep ripping go hand-in-hand. Direct drilling is worthwhile after the ripping has been done because it reduces the erosion risk and helps the effect of deep ripping to last longer. Hard pans can be re-established quickly unless tractor traffic is reduced; and normal cultivation requires more passes of the tractor. It was surprising, and quite worrying, that only four passes of a tractor on a virgin Eradu sandplain soil was enough to form a hard pan which reduced grain yield by 38 per cent.

The following factors should be considered before soils are deep ripped:

- soil type,
- crop type,
- time of ripping (and soil moisture),
- depth of ripping,
- shank spacing,
- speed of working, and
- residual benefit from one ripping.



An excellent response to deep ripping. The plot on the left, ripped just before seeding, yielded 2.4 t/ha. The plot on the right was direct drilled only and yielded 1.4 t/ha (Wongan Hills, 1983)

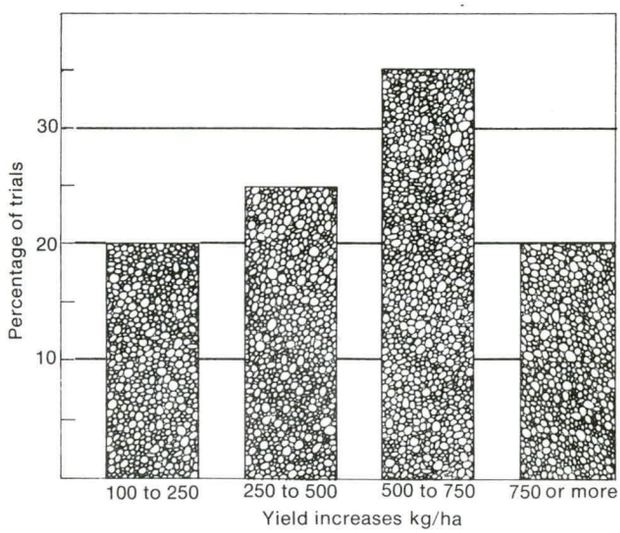
Soil type

Deep ripping has proved extremely beneficial only on light soils. On heavy soils, apparent responses from deep ripping were due to the fallowing effect of the operation which can be obtained cheaper with a shallow working. Research has shown that the soil structure of heavy red clays deteriorates with cultivation. Direct drilling maintains or improves the structure over time and improves yields compared to those following cultivations (see Farmnote No. 39/85, Agdex 102/511).

Measurements from many soil types indicate that the depth of the traffic compaction layer varies according to soil type. The lower the clay content of the soil, the deeper the hard layer. Wongan loamy sands which have 10 to 12 per cent clay, have a hard layer at about 20 cm. Some sites with more clay have a hard pan at 15 cm (the shallowest that has been measured). Yellow earthy sands such as Eradu sandplain have a clay content between 6 and 8 per cent and the hard pan is at 25 cm depth. Deep white sands with a low clay fraction have a pan at 30 cm or more.

Yield increases of wheat from 20 trials on Wongan loamy sand and Eradu sandplain, between 1981 and 1984

The trials have been grouped into four response categories. The percentage of trials in each category is shown. The average response was 490 kg/ha.



continued overleaf

White sands with no apparent pan—the soil strength keeps increasing with depth—have also shown some crop responses to ripping.

Wodgil yellow loamy sands with acid subsoil commonly have compaction pans at 15 to 20 cm. However, crops seldom respond to deep ripping of these soils because root growth responses (and their effect on nutrient and water uptake by the crop) are reduced or don't occur under very acid conditions.

Duplex soils of sand over clay and sand over gravel have traffic hard pans if the sand is deep enough. Generally (but from few experiments) sand over clay soils will not respond to deep ripping unless the clay is deeper than 30 cm. Sand over gravel will respond if the gravel does not restrict root growth too much.

Gravelly soils cannot be measured with the penetrometer, the instrument which gauges the existence of the traffic pan. If conglomerate is close to the surface there will be no response to ripping.

Medium textured soils such as the Avon Valley loams, and fine textured clay loams (salmon gum/gimlet vegetation) have not shown hard pans but soil strength increases with depth. Crop responses to ripping are uncommon, but the ripping operation may occasionally create a fallow and the crop response to the fallow may be confused with a response to deep ripping. This can be checked by comparing the effects of a shallow fallowing cultivation carried out at the same time and alongside the deep ripping.

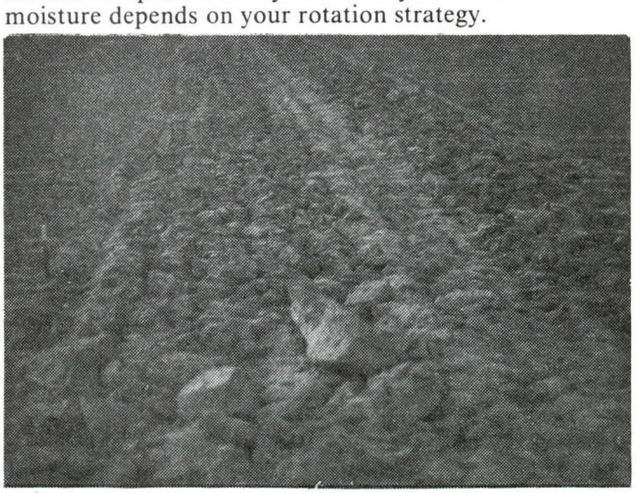
Crop type

All cereals respond to ripping but lupins seldom do. Lupin yields can be lower after ripping if seed is sown too deep in the softer soil. Deeper seeding reduces nodulation and weed control is worse due to dilution of simazine.

In trials where wheat and lupins were grown side-by-side on the same soil, wheat always responded more to ripping. Therefore, for wheat/lupin rotations, ripping should be done before the wheat crop and any possible lupin response will be picked up the following year. However, lupins *must* be sown shallow.

Time of ripping

Ripping is best done when the soil is moist. It is cheaper on fuel and points, disturbs the surface less and softens all the sub-soil profile evenly. Whether you can wait for this moisture depends on your rotation strategy.



Subsoil clods brought to surface from ripping when conditions were too dry

Pasture/crop rotations

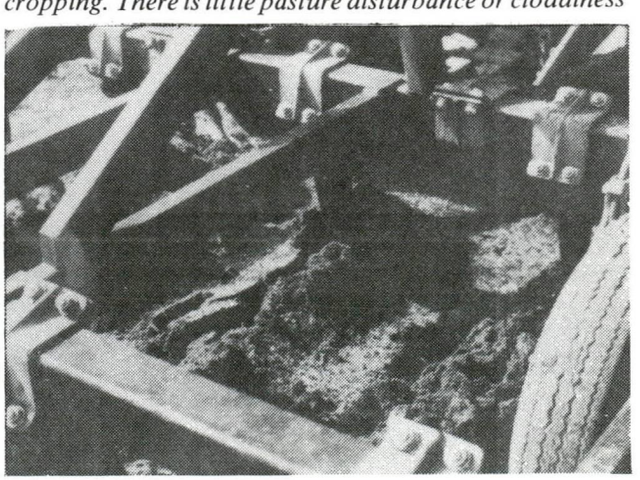
A pasture/crop rotation does not present any problems for a ripping operation. Pasture paddocks can be ripped in July or August the year before the cereal crop. Under moist conditions, good pasture cover and with the right machine (one which hardly disturbs the surface), little pasture is lost from the ripping operation.

Continuous crop rotations

There are three options in a continuous crop rotation:

- Rip after summer rain—but summer rain cannot be guaranteed. For example, in the Geraldton area, the frequency of getting more than 25 mm rain in a three-day period from January to April inclusive is about once in two years, but up to five successive years have passed without such rain.
- Rip moist on the break of the season—but planting is likely to be delayed which will probably reduce yields. On average, yields are reduced by about 100 kg/ha for each week's delay in planting after the end of May. This must be weighed against the yield advantages given by ripping.
- Rip dry—but wear and tear on machinery when ripping dry soil is greater than ripping in wet conditions. More fuel is required and the operation is slower. Also, there may be a penalty from ripping dry soil as it is not as effective in softening the pan evenly, but we do not know exactly how bad this penalty will be. Deep ripping when the soil is too dry can bring large clods of subsoil to the surface. The clods needed to be broken down by cultivation and because the subsoil is less fertile than the topsoil, fertiliser requirements are probably raised.

Ripping pasture in ideal conditions in the year before cropping. There is little pasture disturbance or cloddiness

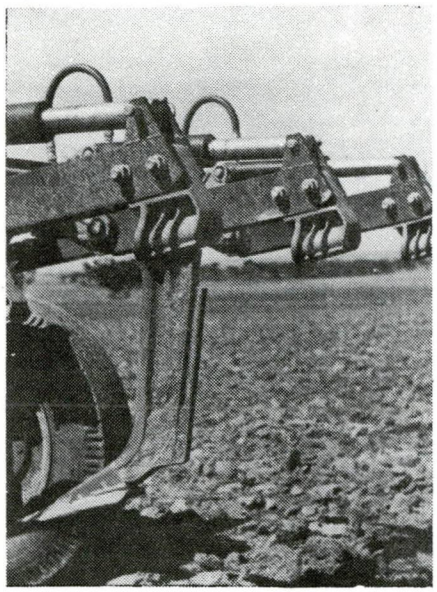


Depth of ripping, shank spacing and machines

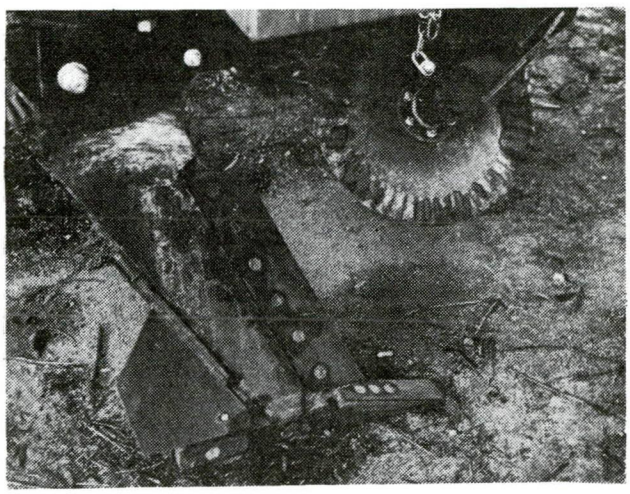
The compaction pan is a thick layer (up to 15 cm thick) and all of this barrier must be removed for maximum yield response. Soil softening is not as deep between the tynes as near the points, and the wider the tyne spacing the less the softening will be in the spaces. A combination of spacings by depths will be tested in 1985.

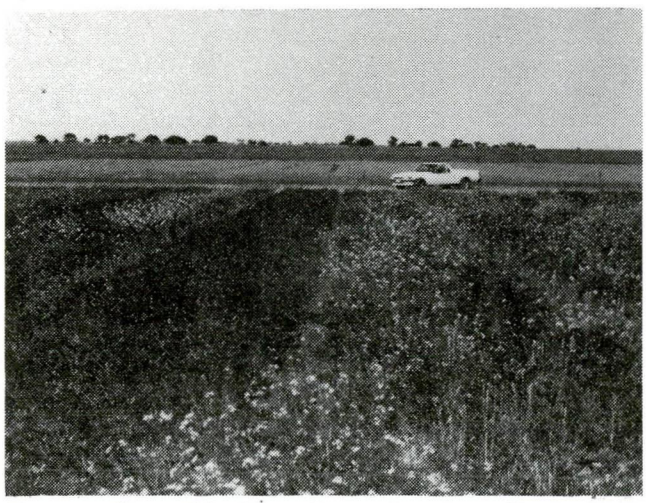
With current machinery (average 30 to 33 cm tyne or shank spacings) aim to rip at a depth of 30 cm. Shallower workings may not achieve maximum response but may be a compromise if much ground has to be covered or if machinery on hand has limitations. Deeper workings would be easier in subsequent years.

and compare all machines. Most [illegible] ploughs are unable to reach the depth required without the tynes dragging back, so the soil between the tynes is not loosened effectively. A trial on Wongan loamy sand in 1984 showed a large response when two machines specifically designed for deep ripping were worked at 30 cm depth. The Agrowplow® softened the soil better, because of its closer shank spacings, and produced a better yield than the Paraplow® at 9 km/h, but not at a slower speed.



Two specialised implements for deep ripping: the Agrowplow® (left) and the Paraplow® (right)





Deep seeding of lupins reduces simazine effectiveness. The plot on the left was sown shallow but the plot on the [illegible]as sown deep (it had been ripped) and radish poor.

Speed of [illegible]ng

[illegible] speed of working can alter the effectiveness [illegible]e o[illegible]tion and fuel consumption increases as speed reases (see Table). These values will vary, depending n soil moisture and the actual depth of working, but they are a useful guide.

The problem, when considering deep tillage, is to know what size "ripper" to purchase to match the existing tractor. Information from the Table can assist this decision. Also, figures for the two-hour maximum drawbar power of your tractor are needed. These figures are based on Nebraska tests and are often presented in Power Farming Technical Annuals. The Dryland Research Institute of the Department of Agriculture at Merredin has a complete list of these figures and can be contacted for assistance.

Table 1. Speed, power requirement and fuel consumption relationships for an Agrowplow® working a moist soil at 30 cm depth

Speed km/h	Unit power kW/m	Fuel consumption L/ha	Fuel consumption % increase on 3 km/h
	Sandy loam		
3	13	16	0
5	24	18	11
7	38	20	22
9	53	22	33
11	70	24	44

Unit power is the tractor drawbar power (Nebraska test) required in kilowatts per metre width of implement.

Example: A Steiger CM-325® tractor is to deep rip a moist sandy loam. Nebraska test No. 1236 shows that the two-hour maximum drawbar power is 201 kW. The width of Agrowplow® can be calculated for each working speed.

At 5 km/hr:

From the Table, unit power required is 24 kW/m. The width of Agrowplow® at this speed is found by dividing the two hour maximum drawbar power figure by the unit power. Therefore, width is: 201 kW divided by 24 kW/m; which is 8.37 m (25 tynes).

Maximum work rate can also be worked out:

$$\text{Maximum work rate} = \frac{\text{width x speed}}{10}$$

$$= \frac{8.37 \text{ x } 5.0 \text{ ha/hr}}{10}$$

= 4.18 ha/hour, and fuel consumption (from Table) is 18 L/ha.

continued overleaf

At 9 km/h :

Width	= 3.79 m (11 tynes)
Maximum work rate	= 3.41 ha/h
Consumption	= 22 L/ha

Note: The practical work rate is usually about 80% of the maximum.

The slower working speed has a better fuel consumption and work rate but a higher implement purchase price. These figures can be used to make rational decisions about the trade-off between capital and operating costs.

Most tractor manufacturers now recommend not travelling under 8 km/h at *full engine power* as the final drive torque is greatly increased and may void the warranty.

Residual benefit from deep ripping

The benefit from deep ripping lasts. Four seasons after a single ripping, a yield response was still obtained at Yorkrakine and Wongan Hills. In 1984, in the second crop after ripping, an extra 500 kg/ha was produced on an experimental site at Wongan Hills but a new ripping produced an extra 1.0 t/ha. Results from eight experiments indicate the residual benefit of the ripping, in the second year, is about half the initial response.

Direct drilling

Re-compaction of a traffic pan depends on the amount of traffic on the paddock when the soil is wet. Reducing the traffic slows re-compaction, so direct drilling after deep ripping will lengthen the duration of the ripping benefit.

The need to reduce tractor traffic over paddocks may mean that the economics of aerial spraying and topdressing, and the use of compound fertiliser at seeding should be re-examined.

Contributing officers

R.J. Jarvis, Division of Plant Research
G.P. Riethmuller, Dryland Research Institute, Merredin
C. Henderson, Geraldton Regional Office
J. Hamblin
B.J. Hillman, Information Section

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Western Australian Department of Agriculture

Agdex 102/511

Direct drilling: soil type recommendations

By R.J. Jarvis, Research Officer, Division of Plant Research

Direct drilling of cereal crops will increase yield considerably on fine-textured, heavy soils in Western Australia. On other soils, the main advantage is reduced erosion risk.

This Farmnote pools eight years of work by the Department of Agriculture which compared direct drilling of cereal crops (when mechanical cultivation for weed control is replaced by a herbicide spray) with normal crop establishment (usually: work-up, work-back then sow) on six soils.

General recommendations are:

- Cultivations should be reduced on fine-textured soils to avoid further degradation of soil structure. Direct drilling with a combine will increase grain yield after the first couple of years provided weeds can be controlled with herbicides.
- Direct drilling is desirable on coarse sandy soils to reduce the risk of wind erosion. However, yields are lower from direct drilling with currently available (1984) machinery. Seeding machines which cultivate deeper than the seed placement are required to improve grain yield. On sands with acid sub-soils, tillage method has little effect because root growth is severely limited by acidity.
- Well-structured soils can be maintained under a direct drill system. Lack of cultivation of these soils does not reduce yield, and reduces the risk of erosion and soil structure degradation.
- Most direct drilling in W.A. is done with combines or cultivator bars connected to air seeders. With this degree of ground disturbance, seed and fertiliser rates need not be increased above those recommended for cultivated situations.

Heavy salmon gum, gimlet soils

Direct drilling with a combine has improved yields, soil structure and organic matter levels in long term trials at Merredin. This has been the result under either a continuous cropping or wheat/medic rotation. Direct drilling is the only suitable way to intensively crop heavy, fine-textured salmon gum and gimlet soils.

In the first few years, it is difficult to get the combine to penetrate the soil. A shallow cultivation may be required, or gypsum could be added to make direct drilling possible. In 1983, gypsum was applied at 5 t/ha to some of the conventionally cultivated plots. It improved the friability of the soil and gave a better seedbed, better crop establishment and an increased yield of 160 kg/ha in the first year and 600 kg/ha the next year (when the gypsum had fully dissolved into the soil). However, yields still did not reach those from areas which had been direct drilled for eight years in a row. The use of gypsum is covered in Farmnote No. 32/85—Gypsum improves soil stability (Agdex 514).

Yield data from Merredin is summarised in the Figure.

Medium-textured York gum and jam soils (Avon Valley)

A sandy loam/York gum site at Avondale Research Station has been continuously cropped to wheat since 1977. All crop establishment techniques produced similar average yields (about 2.5 t/ha), including direct drilling with a triple disc drill following Spray.Seed® application.

Continuous cultivation appears to be degrading the structure of this sandy loam slightly, but there is not the large difference between treatments seen on the heavier soil at Merredin.

A wheat/clover rotation experiment on sandier jam soil showed little difference between the two cropping methods on average but with a large advantage to one method in some years.

Clover levels in pasture increase after direct drilling.

Loamy sands

Sandy soils, such as Wongan loamy sand and tamma country do not improve with direct drilling. They have little soil structure or continuous pore spaces to allow fast root growth. Conventional cultivations (and deep ripping) softens the soil allowing faster early root growth thus faster plant growth and better yields. Also, cultivation lessens the problem of rhizoctonia patch, a seedling root disease.

However, cultivation is undesirable as wind erosion can be a major problem. Direct drilling is safer. A machine which will cultivate to about 10 cm but seed shallow in the one pass, has to be developed. At present, an alternative is to scarify immediately before seeding or pull both scarifier and combine during the seeding operation. Average yield response to the cultivation has been 11 per cent.

Deep ripping (soil loosening)

The sandy soils respond to workings of about 30 cm deep. Tractor traffic over the years has compacted a layer about 20 cm below the surface. Removing this root-restricting layer allows faster root penetration. Deep ripping will probably over-come the need for shallow cultivation before seeding in the year of the ripping but may not in subsequent years although the compaction pan remains broken.

Yield responses from ripping have been phenomenal. In 1983 at Wongan Hills Research Station, an extra 1.2 t/ha wheat was obtained after one ripping. Several other trials have recorded increases of 0.6 t/ha, and most importantly, the effect appears to last. Four seasons after a single ripping, a yield response was still obtained at Yorkrakine and Wongan Hills. In 1984, the treatment at Wongan Hills produced an extra 500 kg/ha without further ripping but a new ripping produced an extra 1.0 t/ha. Results from eight experiments indicate the residual effect of the ripping is about half of the initial response.

Re-compaction of a traffic pan depends on the amount of traffic passing over it when the soil is wet. Less traffic slows re-compaction, so direct drilling after deep ripping will lengthen the duration of the ripping benefit.

Large responses have also been shown on Eradu sandplain and deep ripping can now be recommended on most of the good yellow sandy soils where spring rains are reasonably reliable.

Wodgil sandplain

The Wodgil soils, with very high acidity in the sub-soil, do not need cultivation or deep ripping. While compaction pans can be formed, deep working does not appear to improve wheat yields. Advantages from removing the pan may be lost when the roots reach the acid sub-soil. Acid-tolerant cereal rye or triticales are to be tested in this situation.

Continuous wheat cropping on Wodgil soil at Merredin showed direct drilling is as good as cultivating.

Esperance sandplain

White sand over gravel at varying depths behaves similarly to the good yellow sandplain soils of the wheatbelt in a wheat/pasture rotation. That is, they require a cultivation to release nitrogen and to enable fast, early root growth. In experiments over eight years, cultivated treatments have out-yielded treatments that were direct drilled with a combine every year. Direct drilling with a triple disc drill gave the lowest yield.

Rhizoctonia patch disease is a problem around Esperance and is generally worse in uncultivated situations. Ways to reduce rhizoctonia, using tillage methods which will not predispose the soil to wind erosion, are being studied. The modified combine mentioned previously is one possibility. Another is deep ripping, and in 1984, rhizoctonia was reduced and wheat yields increased by 700 kg/ha from one deep working with an Agrowplow® which creates little surface disturbance.

On the continuous wheat site at Esperance, response to seeding method was different from Wongan Hills. Direct drilling with a combine out-yielded traditional cultivation on average, and direct drill with a triple disc drill has been the best. A combination of weed, disease and nitrogen factors have been more important at Esperance than the cultivation of the seedbed. However, nitrogen responses have been so large that it is questionable whether continuous wheat is viable.

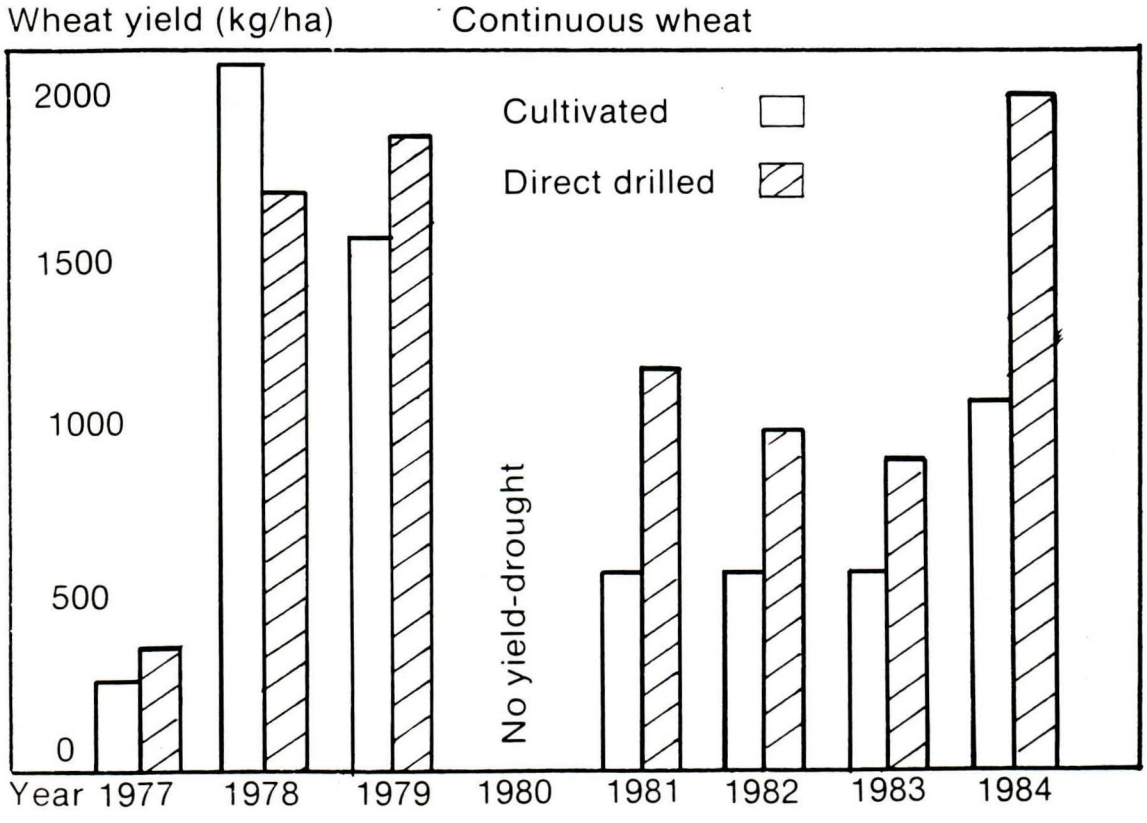
Gravel-loam forest soil: Mt Barker

The results from the two trials at Mt Barker Research Station are similar to those from the loams of the Avon Valley. Direct drilling, on average, yields the same as district practice. Cultivation is not required.

Yields at Mt Barker have been limited by take-all. From 1980 to 1983 over 95 per cent of plants had some take-all root rot in the continuous wheat site. By comparison, a lupin/wheat rotation included in the trial since 1981 had only 20 per cent of wheat plants infected in the year after lupins. From 1982 to 1984, the average yield of wheat after lupins (over all tillage methods but with no nitrogen applied) was 2,593 kg/ha compared to 1,454 for the same 3 years from the continuous wheat (with an average of 63 kg/ha nitrogen applied).

Direct drilling with a combine has given slightly better lupin yields than other seeding methods over the four years that they've been included in the trial.

In the wheat/pasture rotation experiment, direct drilling with a combine has produced the same yield as cultivations (2.3 t/ha). Early seeding is less important in this high rainfall, long growing season area, but the direct drilling system offers the opportunity for extra grazing before spraying and seeding.



Wheat yields from direct drilled and cultivated treatments on heavy red clay at Merredin

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Farmnote
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Western Australian Department of Agriculture

Agdex 572
Water erosion

Direct-drilling on the contour to control erosion

By Tim Negus, Officer in Charge, Narrogin District Office

Direct-drilling crops on the contour, between well-built banks, within the overall framework of a conservation farm plan, is an effective system of water erosion control, even during the most extreme early winter rains.

The benefits of direct-drilling on the contour were seen in an aerial and ground survey of farms around Narrogin in 1983. This survey compared the extent of erosion damage on farms with completed farm plans (which allow the best possible contour working pattern), with neighbouring farmers who work square paddocks without contouring.

The survey was conducted in late July 1983 after the heaviest early winter rain for at least 20 years. In one 12-day period (June 28 to July 9) 125 mm of rain were recorded at the Narrogin Weather Station. The rain fell in two, two-day periods of heavy and intense storms.

The three elements of this erosion-control system each have some ability to prevent water erosion but have the greatest effect when used together.

Direct-drilling

Direct-drilling involves sowing a crop with one cultivation only. The only way to disturb the soil less is by using a triple-disc drill, which sows in slots in undisturbed pasture.

Direct-drilling is an important component of a water erosion control system for several reasons:

- Soil exposure is minimized. This is a very important benefit of direct-drilling.

Under conventional cropping, seven to ten days lapse between ripping up and working back to allow weeds to germinate. The working back operation may or may not achieve a satisfactory weed kill depending on weather conditions; in wet years two or even more workings may be needed before seeding.

With conventional cropping systems, bare soil can be exposed between ripping up and crop tillering for as long as 12 weeks. Direct-drilling delays soil exposure until the day of sowing and reduces the danger period for erosion to about eight weeks.

In this way direct-drilled paddocks often avoid erosion, because they are still under pasture or have just been sprayed when early winter rainstorms strike.

- Soil surface is cloddier and less prone to erosion. Direct-drilled paddocks maintain a cloddy surface with plenty of root and sprayed pasture on the surface to help resist erosion and increase infiltration of rain by keeping the surface open.

At Avondale Research Station, near Beverley, trials have shown that more rain infiltrates into soil that has been direct-drilled using a combine, than after conventional cultivation.

Farmer observations support these results.

- Soil loosening is shallower. Direct-drilled paddocks are usually cultivated less deeply than conventional paddocks. If run-off is servere, erosion will be shallower, as the soil is often stripped to the depth of cultivation.

Direct-drilled paddocks are often firmer than conventionally cultivated paddocks; consequently there is less danger of leaving deep wheel marks during post-cropping of spraying and topdressing. These wheel tracks may be the starting points for erosion.

Contour working

The aerial survey showed that much soil erosion was related to cultivation furrows running straight or diagonally up and down slopes. The importance of cultivating as close to the true contour as possible cannot be over-emphasized. Even at the ends of contoured lands, if bank spacings are too wide, up-and-down workings can erode.

Contour banks

Banks are still essential to handle the run-off from high water shedding areas, like breakaway faces, mallet hills, rock outcrops and shallow clay areas. Water volumes generated on these areas are great enough to erode cultivated soil.

This run-off can only be handled safely by collecting it in contour banks and if possible diverting it to a disposal point in a well-grassed waterway.

To work effectively, contour banks must be big enough to stop overtopping; no less than 50 cm high for grade banks built with a plough or grader. Absorption banks, which store run-off and then let it soak away, must be least 100 cm high. They should be constructed with a bulldozer.

In many situations, conventional contour banks with a shallow channel to 15 cm deep are not cutting off sub-surface seepage flows. Consequently, large waterlogged areas ooze groundwater for long periods and cannot absorb rainfall. Apart from loss of income from a failed crop, these areas produce much run-off, which causes erosion on the seepage area or downslope from it.

To counter this problem, seepage interceptor drains rather than conventional grade banks may be justified, if the paddock is frequently cropped and is waterlogged regularly.

Conservation farm planning

The Conservation Farm Plan aims to integrate all those factors important for the correct land-use management of a property. Parts of the farm susceptible to water and wind erosion, salinity, waterlogging and flooding are identified. Solutions to these problems are devised and the recommendations documented on an air-photo master plan.

For water erosion, the plan deals with erosion on cropping paddocks, on firebreaks and vehicle tracks and erosion caused by livestock at focal points such as gateways, watering points and between rock outcrops.

The final step in the farm plan is to devise remedial measures such as contour banks and drains and an improved paddock fencing layout to fit the land.

The location of fences influences the direction of cultivation furrows, as most working is carried out parallel to fence lines. If the fences are up-and-downhill or steeply across and down slope, the cultivation furrows will be also.

To achieve good run-off control by contour working between contour banks, plan fencing to give long contour working lands. Correct siting of fences along contour banks and ridge crests will help to achieve this aim. Fences in these positions also suit vehicle tracks and firebreaks due to the small amount of run-off that is collected and diverted along the wheel tracks and furrows.

Artificial diversion of surface flows by tracks can cause problems on cultivated paddocks where the run-off builds up to large volumes and then escapes from the tracks onto cultivated soil.

Conclusion

Even after heavy early winter rains direct drilling crops on the contour, between well built banks, effectively controls water erosion. This system is an integration of the well-proven system of contour farming with the more recent technique of direct drilling, within the overall framework of a conservation farm plan.

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Farmnote
No 75/90
re ces 117/83

Western Australian Department of Agriculture

Agdex 511
Management of specific soil types

Managing water repellence in sandy soils

By Bill Crabtree, Adviser, Jerramungup and Doug McGhie, Senior Research Officer

Figure 1. Even pasture growth in late June on a wet soil, treated with 50 L/ha of wetter (left) and dry patchy pasture on untreated, water repellent soil (right).

Water repellent soils are widespread on sandplain soils of south-western Australia. They are soils that do not wet, or have only a thin layer of wet soil - about one centimetre - on the surface after rain. The restricted wetting leads to staggered and patchy germination of crops and pastures.

The problem is worse with a dry, cold break of season. If the soil is warm when substantial rains fall, water repellent soils can wet up well. Once a soil is wet it will usually remain so throughout the growing season.

The more sandy the soil, the more likely water repellence will limit yield. Deep sandy soils with little clay in the surface (less than 5 per cent) are most likely to become severely water repellent. These soils usually wet up from below, since the top 10 cm, the cultivation layer, is the most water repellent. The closer the clay is to the surface, the more quickly the soil profile will fill with water, forcing the water to wet the water repellent topsoil.

This Farmnote gives some background to the water repellence problem and describes possible remedial techniques for crop and pasture establishment. Nine crop trials and one pasture trial, conducted on the south coast in 1987 to 1989, have demonstrated the potential of using furrow sowing, press wheels and wetting agents to improve emergence on water repellent sandy soils.

Problems with water repellent soils

Wind erosion

Because patches can remain dry well into the growing season, these soils are very prone to erosion after they are cultivated.

Weeds

Capeweed and other weeds often germinate in hollows in water repellent soils. Early autumn rains may be funneled to the weeds by their local 'mini-catchments', allowing them to survive until the break of the season. When cropping starts, the surviving weeds may be large and need to be controlled well before seeding, with high rates of knockdown herbicides. If not controlled early, then large weeds may inhibit crop emergence and with other trash, clog seeding machinery.

Reduced pasture production

Pastures on water repellent sands establish in a patchy fashion. Insects multiply and survive on the early-established plants. When the break comes, small newly-emerged plants are attacked by large numbers of insects. The insect damage, along with delayed emergence and reduced plant number, reduces pasture production (see Figure 1).

Causes of water repellent soils

Native state

Before clearing, the native vegetation adds leaf and stem litter to the surface of the soil and dead roots accumulate at greater depths.

The residues of many of these materials are extremely water repellent when they are broken down into fine particles by soil flora and fauna. Small amounts of this material incorporated into soils, particularly sands, form water repellent mixtures.

Many native plants form a water repellent surface soil in their leaf drop zone. This may prevent competition from other plants and in some cases conduct rainfall from within the leaf drip zone to a concentration of roots lying in wettable soils just outside this area.

Annual legumes

The organic residues from annual legume species, particularly lupins and clovers, are water repellent. Under long pasture phases or lupin rotations these water repellent materials accumulate in the soil.

Perennial pastures

Lucerne, in association with fungi in the soil, has caused large areas of severe water repellence in South Australia. Where lucerne is grown on deep grey sand in Western Australia, it may do the same. The water repellence is not necessarily a problem while the actively growing lucerne is able to tap sufficient water from deep sources. However, if the lucerne is killed, re-establishment of lucerne or any other plants can be difficult.

While lucerne forms water repellent soils in association with fungi, perennial veldt grass has extremely water repellent organic matter and water repellence develops from it in the same way as from native species and annual pastures.

Organic deposits

Wind-drifted sands that accumulate along and behind fence lines are usually rich in organic matter and very water repellent. Animal camps or yards can also accumulate plant residues and may become water repellent, since the most indigestible parts of the plant tend to be the most water repellent.

Methods of reducing water repellence

Furrow sowing

Furrow sowing often improves crop and pasture emergence. In furrow sowing, the seed is placed beneath the bottom of the furrow, ensuring that water that ponds in the furrows will be directly above the seed. In conventional sowing, seed is usually placed half-way between the furrow and ridges (see Figure 2).

With furrow sowing, the water infiltrates at various places along the furrow, increasing the likelihood of seeds getting wet. In water repellent soils, the water accumulated in the furrow may run along it before penetrating.

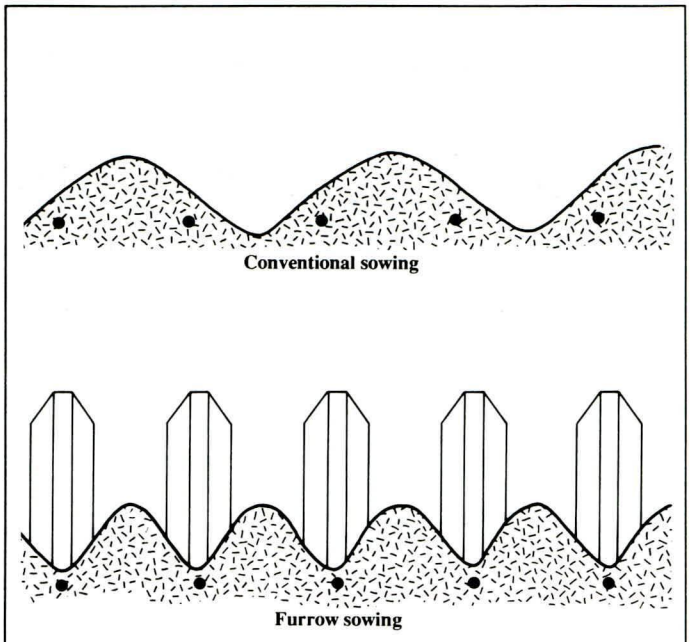

Figure 2. Seed placement with conventional and furrow sowing.

Press wheels

Using press wheels can help achieve furrow sowing and has the added benefit of compacting the surface soil. This compaction improves seed-soil contact and may reduce the potential for wind erosion.

Dry soils do not compact as well as wet soils. Hence the effectiveness of a press wheel for soil compaction is largely dependent on soil moisture. Water repellent soils are most likely to be a mixture of wet and dry soil during the seeding operation.

Seedbeds in these soils often have cloddy patches after cultivating. Press wheels help to reduce these, which in turn improves crop emergence.

Press wheels with indents can also create small dams, which can stop water running down the furrow. They can also improve the efficiency of use of wetting agents that are sprayed in a narrow band at the bottom of the furrow.

Wetting agents

Wetting agents, which decrease water repellence, are expensive to use with broad-acre application. However, recent trials of banding wetting agents combined with furrow sowing using press wheels have shown that cost-effective rates can be used. Wetting agents at 1 to 4 L/ha have given improved emergence of wheat, barley, lupins and pastures and may be useful on large areas of water repellent sandplain soils (see Figure 3).

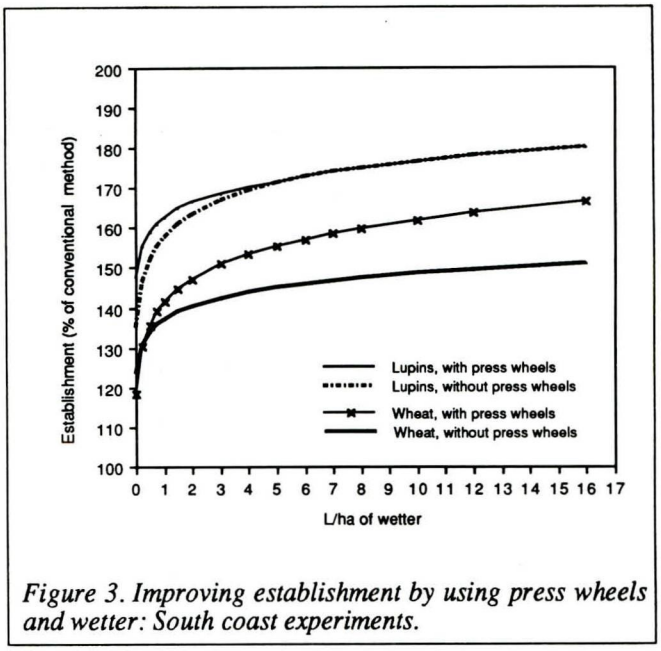

Figure 3. Improving establishment by using press wheels and wetter: South coast experiments.

Figure 4. Wetter being applied in the furrows behind press wheels.

In these trials, the wetting agent was applied in 5 mm bands at the bottom of the furrows. Only 3 per cent of the ground was sprayed (Figure 4). Solid stream nozzles were mounted on a fixed bar behind the press wheels and at 5 km/h, 200 kPa pressure and 180 mm spacings the boom delivered 30 L/ha of the water and wetter mixture.

At this low nozzle output some blockages were experienced, even with the use of 100 micron mesh sieves. Most blockages were caused by travelling with the boom sprayer turned off.

Some farmers plan to band spray using a spray tank mounted in front of a combine, followed by press wheels with nozzles attached behind. More accurate placement will result from following the press wheels with the spray nozzles.

Cultivating in the rain

Farmers at Esperance and in South Australia have improved plant emergence by cultivating in the rain. The mixing of wet and dry soil has resulted in more soil wetness.

This practice is not recommended, because the extra soil disturbance increases the risk of wind erosion, particularly in drier northern areas.

Adding clay or lime

In the south-eastern mallee dune area of South Australia kaolin, an easily slaked clay, is being applied at 25 to 200 t/ha by several farmers. The lower rates have improved soil wetting but are less likely to give quick results. The higher rates have improved sheep carrying capacities by one to two DSE/ha.

The estimated cost of the clay is $1/t where shallow clay is available near to the paddock; the farmers might expect to recoup this over 10 years. Clay application could only be considered by farmers in Western Australia if a good supply of the appropriate clay was available nearby. Banded applications of clay are currently being evaluated in this State.

Applying 1 to 5 t/ha of lime in trials near Albany has also improved soil wettability and consequently pasture establishment. The reasons for this improvement are not known; further trials are being conducted.

Recommendations

Furrow sowing and wetter application

At this stage we have demonstrated the effectiveness of wetting agents with furrow seeding and press wheels but we have no local experience with clay and only a little with lime applications, so that the former method is recommended.

If water repellence is causing delayed crop emergence, then furrow sowing in conjunction with wetting agent at 1 to 3 L/ha will improve cereal and lupin emergence. Using press wheels will improve the reliability of wetter placement, reduce soil clods and may reduce wind erosion.

Established annual pastures may also benefit in a cost-effective way from using press wheels and wetter before the break. They would need to be applied each year, although there may be a residual effect in the bands.

Furrow sowing with a combine is simply achieved. The last two rows of the combine need to be sowing tines, with the front rows providing soil disturbance and weed control. If a full cut is needed, this has to be achieved by the front rows of tines.

With higher speeds the last row of tines may need to have narrow points (2 to 5 cm) attached. Wide points or high speeds result in the soil from the last row of tines burying the previous sowing row.

Press wheels may be in gangs of 4 to 10 and they should trail behind the combine with each wheel running precisely above the sowing furrow (Figure 5).

The type of press wheel to use is not important, as long as it is heavy enough to help form the furrow and is cheap. There appears to be little need to have press wheels heavier than 3 kg/cm.

Using wide row-spacings with lupins

Research in Western Australia has shown that lupins sown with wider row spacings, up to 30 cm, yield as well as with traditional narrow row spacings.

Farmers may be able to sow in more wettable soil by forming wide ridges containing the surface water repellent soil and sowing the lupins in the exposed deeper wettable soil.

Using perennial pastures

Planting perennial pastures can reduce the impact of water repellence in pastures, particularly in cooler areas of the State. The cost of establishing perennials can be low, since wider row spacings are possible. Less wetting agent is required and, once established, these pastures can persist for many years.

Using soil amendments

Small trials on individual farms, using clay or lime, could be worth doing. Such trials should include a 'control' treatment of no added clay or lime, for valid conclusions to be drawn from the results.

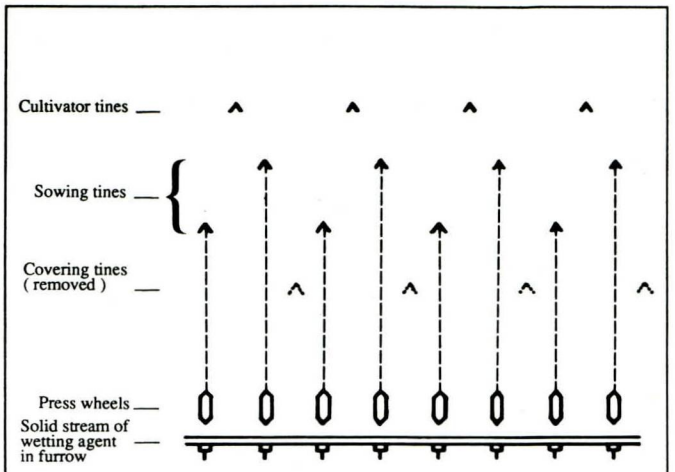

Figure 5. Position of combine tines in relation to the press wheels and wetter.

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Western Australian Department of Agriculture

Agdex 571
Wind erosion and control

Preventing wind erosion

By Dan Carter, Research Officer, Division of Resource Management, Albany

Preventing erosion associated with winter cropping

- Sow crops that emerge quickly.
- Minimize cultivation - direct-drilling is desirable.
- Reduce the speed of cultivation on drier soils. Stop if clouds of dust form.
- Retain 50 per cent ground cover, or 1 t/ha, of straw (incorporated in the soil to anchor it if necessary).
- In grazed stubbles, at least 200 kg/ha of anchored stubble is needed to hold the loose stubble.
- Pea stubbles provide little protection.

Preventing erosion associated with summer grazing

- Grassy pastures give more protection than clover, medics and many weeds.
- A sandy soil needs 50 per cent ground cover or 500 kg/ha of grasses to be stable.

The best way to beat wind erosion is to maintain plant material, either anchored stubble or dry pasture residue, on the soil surface.

The effectiveness of other measures depends on seasonal conditions. Regular, frequent rains would ensure cultivated soil does not dry out to become susceptible to wind - but how often does that happen?

Likewise, while stubble burning exposes the soil to wind erosion, wind would not be a problem if the soil became and remained wet after burning.

Over-grazing and fast, dry cultivation increase the risk of wind erosion. Judgements on what stocking rate is too high or what moisture level is too low for cultivation depend on when the season breaks and when there is follow-up rain. Wind is always present and cannot be avoided.

Research into the causes, effects and control of wind erosion has concentrated on two themes: winter cropping erosion and summer grazing erosion. Both have similar basic principles governed by the soil structure and degree of ground cover.

Winter cropping wind erosion

Wind erosion in the cropping phase is restricted to the time from when the soil is first worked until the crop is sufficiently developed to reduce wind to a non-erosive speed at the soil surface. This takes six to eight weeks after emergence, during tillering and internode elongation.

The period of susceptibility can be lengthened by dry or cold conditions (which delay plant growth) or by previous sandblasting. Crops that emerge quickly overcome the erosion hazard better.

Cultivation

The effects of cultivation on erosion depend on the amount of damage to soil structure. This damage can be avoided by correct timing of the cultivation.

The structure of southern sandplain soils is maintained only by plant roots and soil moisture. The clay content is less than 1.0 per cent and is unable to hold these soils together. Their structure is readily shattered by cultivation at high speeds or when the soil is too dry.

If soil moisture is adequate, it may be possible to maintain high cultivation speeds (up to 20 km/h) without significant damage to soil structure. However, although the effect of speed of cultivation on soil damage at various soil moisture levels has not been fully researched, speed should definitely be reduced if moisture declines.

Cultivation should be stopped when clods are being shattered excessively and sand is being knocked out of the plant root balls. A cloud of dust signals this stage.

Direct-drilling is desirable, because it reduces risks and delays erosion processes long enough to allow the crop to grow and protect the soil. However, direct drilling does not prevent all erosion and there may still be damage if a strong wind blows for long enough. Crop protection by plant residue is the key—do not rely wholly on direct-drilling.

Stubble retention

Stubble retention is a proven method of preventing wind erosion in cultivated soils. Only a small amount of straw is required to prevent erosion. One tonne per hectare or 50 per cent ground cover is needed.

However, anchorage of the straw to the ground, either by incorporation or by residual roots, is the key factor. In a grazed stubble, as little as 200 kg/ha of anchored stubble can hold loose stubble in position to prevent wind erosion.

Stubble height is not as critical as straw spacings. Normal stubble from a 1.6 t/ha crop, when cut to 100 mm (about 400 kg/ha) would resist erosion in most winds. Longer straw is necessary only if the crop is drought-affected and spacing between the remaining plants is increased. In this case wind will penetrate to the soil surface and wind erosion is possible.

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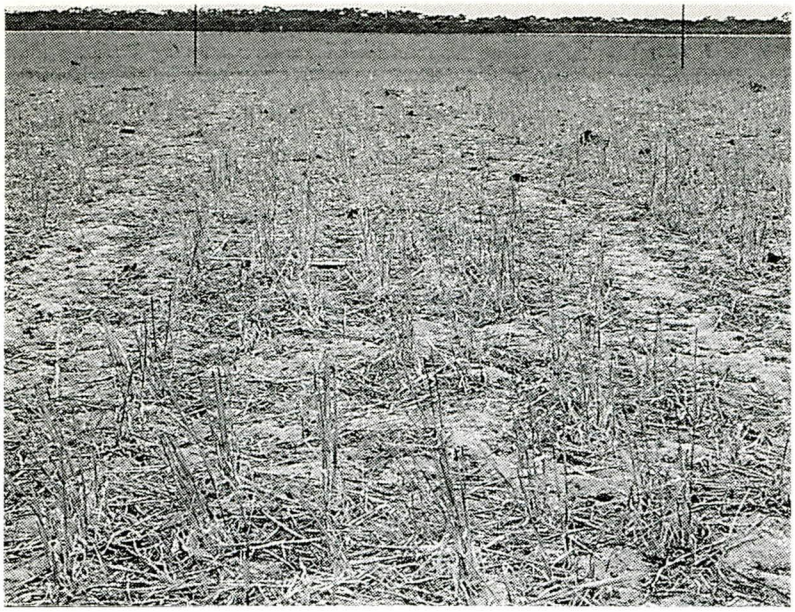

Cereal stubble of 1.4 t/ha, more than enough to minimize wind erosion.

A warning: Growing peas and grazing the stubbles may be followed by disastrous wind erosion. Peas that are grazed break up and blow away, leaving the soil completely bare. This is intolerable on most sandplain soils.

Future direction

The aim of wind erosion research is to develop farming management that will avoid erosion and not, as in the past, repair erosion.

For winter cropping, research into cultivation speeds and their impact on soil structure at different soil moisture levels have shown the benefits of maintaining a stable, cloddy soil surface that resists erosion. Different seeding techniques are being investigated to improve the soil's ability to resist erosion.

The use of ground covers to control wind erosion is not a simple matter of kilograms per hectare because of other factors such as anchorage, percentage cover and plant species. Resistance to wind erosion decreases from perennial pasture to annual grasses, to annual medics, clovers and weeds.

A paddock highly liable to wind erosion, as it has only 0.4 t/ha of cereal stubble.

Summer grazing erosion

Wind erosion during summer and late autumn, before the opening rains, depends on two related factors: detachment of soil and removal of ground cover by grazing sheep.

Soil

A sheep can detach from one third of a tonne of soil per week on a hard-setting soil to over one tonne per week on the sandplain soils. This material can be blown away if there is not enough cover to lower the wind to a safe speed.

Pasture species

The prediction of when minimum ground cover occurs is difficult, because pasture species break down differently when grazed. Many weeds and all legumes are easily broken by sheep trampling and are blown away in moderate winds. Grasses can withstand trampling better and so are able to protect the soil from higher velocity winds.

Ideally, an evenly-mixed sward of clover and grasses will protect soil from erosion. While grasses in pasture encourage some soil insects and diseases, techniques of controlling these problems rather than creating grass-free pastures may be necessary if wind erosion is to be combatted.

The minimum vegetative cover required to hold sandy soils is likely to be 50 per cent ground cover or about 500 kg/ha for grasses. This limit should be used as a guide to calculate the potential grazing for the summer period. The aim should be to leave at least 500 kg/ha of anchored plant material at the latest possible date of the season's break.

New systems

A cropping system with continual stubble retention would be a good development to combat wind erosion. This system would provide a permanent ground cover with valuable grazing, and profitable cropping. However, management and cultivation difficulties would be encountered.

Avoiding wind erosion by soil and cover management also involves recognising danger signals early in the summer, when ground covers are at their maximum, until the next growing season.

Assess likely stubble amounts, pasture production and species composition, so that potential grazing rates over the summer will not remove the plant cover to a point where erosion starts. These assessments can be adjusted as conditions change.

Further reading

- Farmnote No. 40/90 'The amount of stubble needed to reduce wind erosion' (Agdex 571).

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Agdex 571
Wind erosion and control

The amount of stubble needed to reduce wind erosion

By Dan Carter, Research Officer, Soil and Vegetation Management Branch, Albany

This Farmnote details the amount of cereal or lupin stubble needed to reduce wind erosion. It also helps you to predict when a paddock might erode.

The photostandards will help you identify what constitutes an adequate stubble cover.

Wind erosion begins on bare soil surfaces when the wind speed, measured 10 m above ground level, exceeds 30 km/h. The corresponding wind speed at the soil surface would be about 0.3 metres per second or 1 km/h.

To reduce wind erosion, the surface wind speed must be below this threshold, even though the wind speed above the surface exceeds 30 km/h. Surface wind speed can be slowed by maintaining an adequate, stable cover of stubble.

Assessing the erosion hazard

The erosion hazard of a paddock is determined by:

- windiness of the site,
- dryness of the site,
- looseness of the soil surface (that is, the soil surface is easily disturbed), and
- adequacy of the ground cover.

The first condition cannot be controlled, but experience will tell you if winds at a particular site are a problem.

Most areas of the south-west of Western Australia are windy enough over summer and autumn to suffer wind erosion, so there is no escape if the other conditions are conducive to erosion.

You can manage the other conditions by changing grazing rates on the stubbles and by cultivation strategies.

Sheep will remove vegetation and ground cover and dig up and loosen the soil surface if they are allowed. The surface will loosen quickly on sandy soils but this will not be a problem if ground cover is maintained. Even though there might be enough loose soil, the stubble cover prevents the wind from reaching and disturbing it.

Wind erosion starts in the weakest or most exposed part of the paddock, but this initial erosion will not progress unless the rest of the paddock is in a critical condition.

To assess the erosion hazard of the whole paddock you must inspect all parts of the paddock, not just the worst areas. If most of the paddock has less than 50 per cent cover, then remove the sheep.

Sheep camp areas and bare ground around troughs and gates will not be a problem if they are surrounded by adequate stable cover. Sand blown off these areas will be trapped in a short distance by the stable vegetation.

If erosion has progressed, it is likely that the surrounding areas of vegetation were either below the critical levels or unstable. Check this during your overall assessment of the paddock.

Cultivation of stubbles reduces the amount left on the surface. Take this into account when calculating how much stubble should be left after grazing. Generally a scarifier will bury about 30 per cent of the stubble and a disc plough about half.

Stubble requirements for control of wind erosion

The value of vegetative material for control of wind erosion is assessed primarily on the percentage of covered ground. This gives different weights of materials for different kinds of stubble, with the smaller finer stalks such as wheat needing less weight than the coarser lupins.

The critical ground cover percentage is 30 per cent, which means that if all the standing stubble were knocked down on the surface, not less than 30 per cent of the ground would be covered by the straw. However, cultivation will further reduce the amount of stubble so the Department of Agriculture suggests grazing before cultivation should stop when there is 50 per cent cover.

A workable range of coverage is 30 to 60 per cent, with 50 per cent being a safe compromise between only reducing erosion (at a minimal 30 per cent) and having machinery problems that restrict direct drilling operations (at the upper range of 60 per cent).

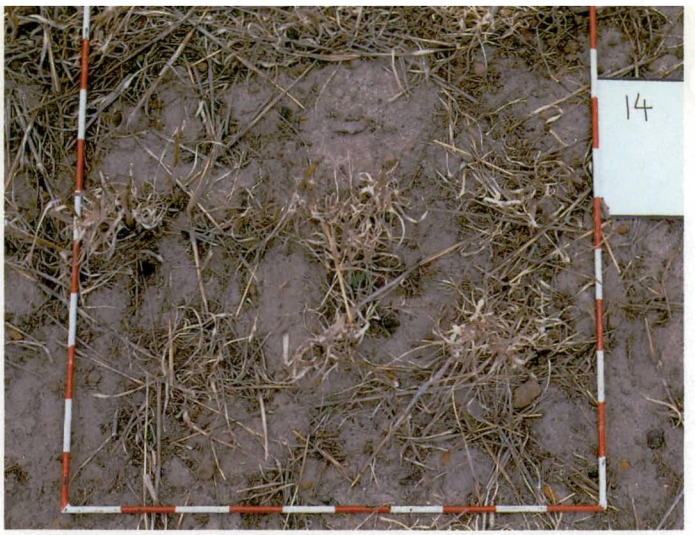
The stubble should contain at least one-third anchored material, so that there is little movement of loose straw in strong winds and this movement is restricted to within the stubble paddock.

If one third of the stubble is anchored the straw will generally hold firm and maintain the coverage, even against gale force winds.

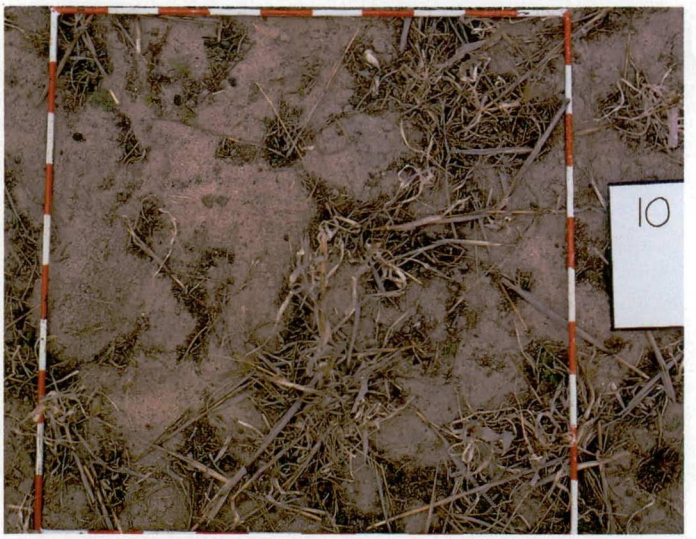
Maintain an adequate level of anchored plants by not letting sheep over graze and pull out the stubbles.

Cocky chaff and loose leaves provide little protection to the soil, and generally are not considered when assessing the erosion hazard.

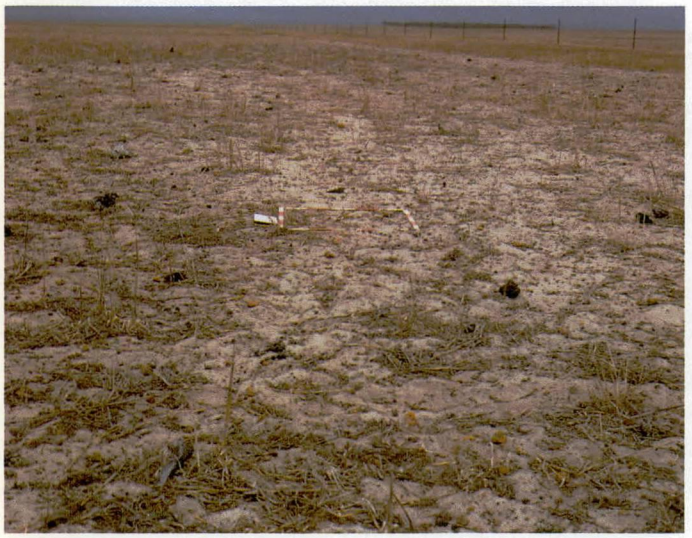
In lupin stubbles, the pods occupy significant space and can contribute to the protection given by the stalks.

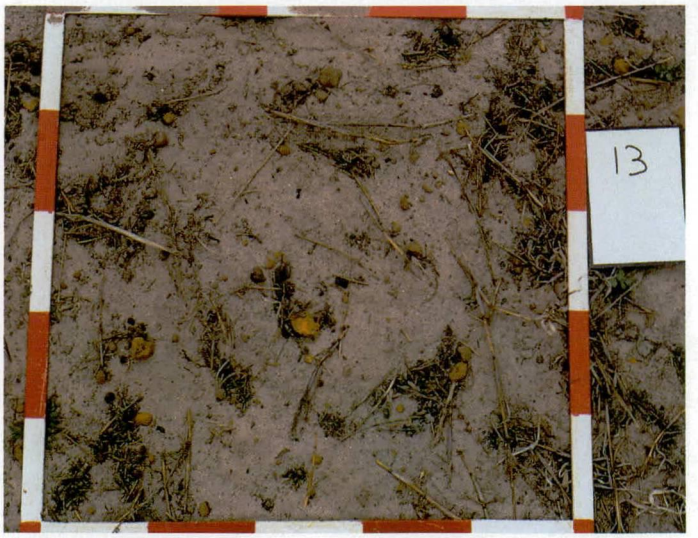


LEFT: An oblique view of 1,400 kg/ha of cereal stubble, more than enough to minimize wind erosion.
RIGHT: The 0.25 sq. m quadrat in this vertical photo represents 1,400 kg/ha of cereal stubble.

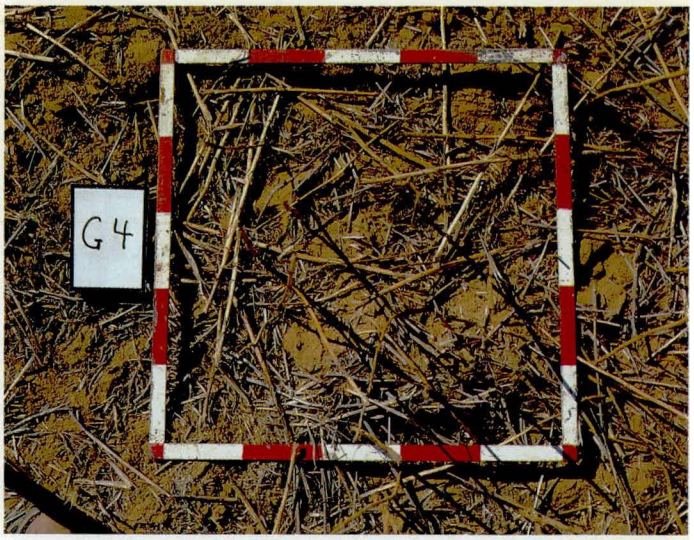


LEFT: An oblique photo of a trial plot representing 1,000 kg/ha of cereal stubble, enough to resist wind erosion. This amount of stubble represents about 40 per cent ground cover.
RIGHT: A vertical view of a quadrat representing 1,000 kg/ha of cereal stubble, or about 40 per cent ground cover.





LEFT: This paddock is highly prone to wind erosion as it contains only 400 kg/ha of cereal stubble, not enough to resist erosion.
RIGHT: The area in the quadrat shows the lack of cereal stubble to resist wind erosion.



LEFT: An oblique view of lupin stubble with enough stubble to reduce wind erosion after cultivation.This amount of stubble represents 6,852 kg/ha, of which 2,812 kg/ha is effective stubble and 4,040 kg/ha is small and loose ineffective stubble.
RIGHT: A vertical view of sufficient (total 6,852 kg/ha) lupin stubble.

LEFT: There is enough lupin stubble in this paddock to minimise wind erosion but it may not be effective after cultivation. There is a total of 2,432 kg/ha of stubble of which 2,008 kg/ha represents effective stubble and 424 kg/ha is small and loose ineffective stubble.
RIGHT: A vertical view of 2,432 kg/ha of lupin stubble.

LEFT: This paddock contains only 816 kg/ha of lupin stubble and all of it is loose. The paddock, as seen in this oblique photo, is highly prone to wind erosion.
RIGHT: A vertical view of 816 kg/ha of lupin stubble cover.

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What weight is left after harvesting?

The table shows how much stubble is left after harvesting 'normal' crops in Western Australia's agricultural rainfall regions and zones. It is based on the stubble yields of the recommended varieties from the Department of Agriculture's crop variety trials.

Knowing the weight of the crop is the important first step in estimating the grazing potential of the stubbles and predicting when a paddock might be an erosion hazard (see 'Estimating grazing potential'.

Grazing sheep eat and trample about 2 kg of stubble per head per day, therefore you can roughly estimate the number of grazing days from the crop yield or stubble left after harvest. You can estimate the grazing days from the time sheep are put into the paddock to the time when stubble cover standards become critical (see table).

If you need six months (180 days) of grazing, then the appropriate stocking rate can be derived from the table by dividing the number of days at 10 DSE/ha by 180 and multiplying the result by 10; for example, 334/180 = 1.86 (x10) = 18.6 DSE/ha.

These estimations take no account of the nutritional requirements of sheep. Hand feed sheep for maintenance of body weight over this period.

If you plan to crop the paddock, leave more residues to compensate for those buried by cultivating implements.

How to use the photostandards

The photographs of the various amounts of stubble are to be used as a guide for estimating the stubble in a paddock.

Two sets of photographs are shown: one taken from the vertical and the other from an oblique angle looking towards the horizon. The latter will give a more natural appearance of the stubble when viewed from some distance. However, the vertical photograph will give the true picture of percentage ground cover.

For cereal crops, 750 kg/ha stubble corresponds to about 30 to 40 per cent standing cover - the critical amount to prevent wind erosion. Because lupin stalks are heavier than cereals, 1,500 kg/ha of lupin stubble is needed to reduce wind erosion.

The photostandards also show levels above and below the critical amount for cereals and lupins.

Use the photostandards a month or two *before* the critical level will be reached - in late summer to early autumn. If most of the paddock, excluding the troughs and camping areas, is at the critical level remove most of the sheep immediately.

If you plan to crop the paddock, keep the amount of stubble after cultivation and seeding above the critical level. As tyned seeding implements tend to bury about 30 per cent of the existing stubble, take this into account when deciding on when to remove stock. The amount of stubble remaining *before* cultivation should be greater than 1 t/ha for cereals and 2 t/ha for lupins.

Estimating grazing potential

Use the following equations to give an approximate guide to the grazing potentials of cereal and lupin stubbles:

$$\text{No. of grazing days (DSE†/ha)} = \frac{[\text{stubble level (kg/ha)} - \text{critical level (kg/ha)}]}{\text{removal rate (2kg/hd/day)} \times \text{stocking rate (DSE/ha)}}$$

OR

$$\text{Stocking rate (DSE/ha)} = \frac{[\text{stubble level (kg/ha)} - \text{critical level (kg/ha)}]}{\text{removal rate (2kg/hd/day)} \times 180 \text{ days}}$$

†DSE = dry sheep equivalent

Critical levels: 750 kg cereal stubble per hectare
1,500 kg lupin stubble per hectare

A range of crop yields and after-harvest stubble yields, with estimates of grazing days to the point of critical ground cover

Type of crop	Crop yields (t/ha)								
Wheat									
Grain yield (t/ha)	4.0	3.6	3.2	2.8	2.4	2.0	1.6	1.2	0.8
Stubble yield (t/ha)	7.4	6.7	5.9	5.2	4.4	3.7	2.9	2.2	1.5
Grazing days (10 DSE/ha)	338	297	260	223	185	148	111	74	37
Oats									
Grain yield (t/ha)	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4
Stubble yield (t/ha)	6.0	5.4	4.8	4.2	3.6	3.0	2.4	1.8	1.2
Grazing days (10 DSE/ha)	263	233	203	173	143	113	83	53	23
Barley									
Grain yield (t/ha)	3.8	3.4	3.0	2.6	2.2	1.8	1.4	1.0	0.6
Stubble yield (t/ha)	6.8	6.0	5.3	4.6	3.9	3.2	2.4	1.8	1.0
Grazing days (10 DSE/ha)	300	265	229	194	158	123	87	51	16
Cereal rye									
Grain yield (t/ha)	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4
Stubble yield (t/ha)	4.9	4.4	3.9	3.4	2.9	2.4	1.9	1.4	0.9
Grazing days (10 DSE/ha)	207	183	158	134	109	85	60	36	11
Triticale									
Grain yield (t/ha)	3.8	3.4	3.0	2.6	2.2	1.8	1.4	1.0	0.6
Stubble yield (t/ha)	8.4	7.6	6.7	5.8	4.9	4.0	3.1	2.2	1.3
Grazing days (10 DSE/ha)	385	341	296	252	207	163	118	74	29
Lupins									
Grain yield (t/ha)	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4
Stubble yield (t/ha)	6.0	5.4	4.8	4.2	3.6	3.0	2.4	1.8	1.2
Grazing days (10 DSE/ha)	225	195	165	135	105	75	45	15	-15

Note: For wheat, 5 bags/acre = approximately 1.0 t/ha

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Western Australian Department of Agriculture

Agdex 117/10
Rye-triticale/management

Cereal rye - a crop for stabilizing erosion-prone soils

By Dan Carter, Research Officer, Albany and Paul Findlater, Research Officer, Division of Resource Management

Cereal rye tolerates infertile and sandy soils and withstands sandblasting much better than other cereals. The straw is tough, both when growing and when mature, and it remains standing throughout summer, providing good protection for the soil.

Cereal rye, therefore, is used to stabilize eroded farm land, coastal sand dunes and areas disturbed by surface mining, building or engineering works. If relying on rainfall, the crop can be planted from early winter to mid-August. Irrigation is necessary if the crop is planted at other times. The crop must be planted early in winter if the grain is to be harvested.

The plant

A distinguishing feature of young cereal rye is that is has four primary roots originating from the seed.

The root system branches extensively in the first 30 cm of soil and is more developed than the roots of wheat or oats. As it can send out roots and tillers from the second, third or even fourth node, rye can be sown deeper than wheat. This feature is useful when sowing on eroded or disturbed sites, where depth of sowing is difficult to control.

Rye stems are tougher, longer and more slender than those of other cereals. A characteristic of rye is the purple colour of both the young plants and the leaf sheaths of the older plants.

The ears of rye are bearded, longer and more lax than those of wheat; they set only two grains wide.

Unlike other cereals, rye is cross-pollinating and relies on the wind to carry the pollen. Seed set varies from 60 to 80 per cent according to the variety and the season. In a hot dry season, much of the pollen is killed by loss of moisture before it can fertilize another rye flower.

Rye can withstand freezing conditions better than wheat and is commonly grown in northern European countries.

Rye has a fairly long grain-formation period. The grain is long, narrow and usually dark. Porous bread can be made from it because the grain contains gluten.

Varieties

The major recommended variety is South Australian Commercial, which is higher yielding than all other varieties in Western Australia. The New South Wales variety, Weethalle, is probably the next best alternative to South Australian Commercial, but is much lower yielding in all areas. All other varieties tested, including Strain-8, NIAB and the local West Australian Commercial (Slav), have been lower yielding.

Because of the limited market for cereal rye, pedigree seed is not available from the Department of Agriculture. Seed more than one season old should be tested for germination by the Department, because the seed deteriorates more rapidly than that of other cereals.

Commercial seed for planting may sometimes be difficult and costly to obtain. During or following a season when many crops have been sand blasted and more sand drift areas have developed, demand for rye seed increases greatly.

Cultivation

When grown as a grain crop, rye has similar cultural and fertilizer needs to wheat. Sow at about 40 kg/ha but, because the seed tends to flow through the combine more easily than wheat, adjust the gears. Seed 3 to 4 cm deep, although it can be sown deeper.

When grown as a crop to control erosion, rye must be sown as soon as possible after the opening rains. Use cultivation or seeding machinery slowly and only when the soil is wet. Do not use covering harrows behind the seeding machine.

On eroded or disturbed sites, the soil need not be cultivated before sowing rye, but the seeding rate should be increased to about 100 kg/ha. On these sites, fertilizer rates should also be greatly increased.

Inland eroded situations, such as yellow sandplains

Apply superphosphate at up to 300 kg/ha plus minor elements appropriate to new land in the district. The exact rate of superphosphate will depend on how much of the surface soil has been removed.

To supply nitrogen, apply Agran 34-0 at 25 kg/ha (or its equivalent) at seeding, preferably with a further 25 kg/ha six weeks later.

Disturbed coastal and engineering sites

Apply No. 1 mix of superphosphate, copper, zinc and molybdenum at 400 to 500 kg/ha. The exact rate will depend on whether any of the original surface soil remains or has been replaced.

Use Agran 34-0 at 50 kg/ha (or its equivalent) at seeding, followed by a further 50 kg/ha six weeks later.

Rehabilitation after mining mineral sands

Apply the No. 1 mix of superphosphate at 400 to 500 kg/ha and, in four applications, Agran 34-0 at 100 kg/ha (or its equivalent). The nitrogen (Agran) should be applied first at seeding and then at monthly intervals. Repeated applications are required because of rapid leaching of nitrogen in these sandy soils. Applications at seeding and in spring are particularly important.

With sandplain lupins

When sown with sandplain lupins (*Lupinus cosentinii*), cereal rye provides a protective cover, allowing dense stands of sandplain lupins to grow in the second year. This strategy is well suited to the unproductive deep grey sands.

It is essential to test the germination of the sandplain lupins. They should be sown at greater than 30 kg/ha, with the cereal rye.

The fertilizer requirement for cereal rye should be adequate for the lupins. In the second and subsequent years, if phosphate levels are reasonable (more than 8 ppm), then only apply superphosphate at 100 kg/ha.

Grazing

Rye becomes unpalatable to stock once the plants begin to elongate. Even as the grain is maturing, stock avoid eating the ears because they are too coarse for them. If rye is to be cut for hay, cut it at an earlier stage of growth than a similar oat crop, but not later than flowering.

Rye used to stabilize an area or trap drift sand should not be grazed. Temporary fencing may be necessary if only part of a paddock is sown to rye and the balance is required for grazing during the growing season.

Grain

Rye is required in small amounts for specialities such as rye bread. There is some demand for it as a component of stock feed mixes prepared for sale by commercial firms. It is also used on farms as an alternative to wheat for grain feeding of sheep, but usually only by those farmers who have grown their own supplies.

The likely benefit of growing rye for sale is unpredictable because of the fluctuations in demand for seeding of wind-eroded areas. In a year of high demand, farmers with stocks on hand (possibly originally kept for grain feeding) can command good prices. When supplies are short, seed can be brought in from South Australia, but this involves extra freight costs.

In the past, seed rye has been $17 per 50 kg bag.

Triticale - a possible alternative

Man-made crosses between cereal rye and wheat have produced a new crop species called triticale. Several varieties released in other states are now being grown in Western Australia. In limited tests, Ningadhu has yielded well in high rainfall areas (more than 450 mm) but it may not outyield cereal rye in these areas. Coorong and Tyalla outyield cereal rye in medium and low rainfall areas (below 450 mm)

Triticale grown on good non-eroded soils recovers from sandblasting equally as well as cereal rye, but it has not been tested on poor, eroded soils.

Triticale should be given the same cultural treatments as wheat, with perhaps a slightly higher seeding rate (60 kg/ha) to compensate for its slightly larger grain.

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Farmnote
No. 21 /91

Western Australian Department of Agriculture

Agdex 510
Soil management

Landcare at low or no cost

By Tim Negus, Manager, Landcare Assistants' Training Scheme, Division of Resource Management, Narrogin

Western Australian landholders may be tempted to consider that land conservation is something that can be afforded only in years of good financial return.

A more realistic viewpoint is that Landcare is an integral part of good farming and that there are many aspects of land conservation that are of low cost and often can be accomplished at no cost.

These low or no-cost techniques are usually simply a matter of common sense, attention to detail, a little hard work and a caring attitude towards the land.

The purpose of this Farmnote is to suggest many low or no-cost techniques for prevention or control of water and wind erosion, soil salinity, tree decline, waterlogging and farm water deficiency.

Although many of these ideas may appear to be common sense or 'old hat', it is surprising how often mistakes are made.

Water erosion

- Reduce the cropping intensity of erosion-prone paddocks.
- Don't rip up grass waterways.
- Leave grass waterways wide enough, for example 20 m or more. Your local Department of Agriculture technical officer can design the correct width.
- Never drive vehicles up waterways or around the discharge ends of contour banks.
- Work on the contour if the paddock tends to wash.
- Build contour banks at least 60 cm high and with a 350 cm-wide channel, with a disc plough.
- Maintain contour banks every three to five years to keep the bank 60 cm high.
- Push extra soil into weak sections of a bank with a front-end loader, for example at gullies and ridges.
- Don't drag cultivating machinery over banks.
- Use minimum tillage or direct-drilling on paddocks which wash or blow.
- Don't cultivate or seed up and down 'funnel' headlands.
- Locate tracks and firebreaks along ridge tops and on the contour to stop them collecting run-off. Never run tracks or firebreaks downhill alongside waterways.
- Reduce firebreak erosion by using herbicides rather than a scarifier. Don't use a plough to form firebreaks.
- Locate gateways on ridge tops and on soils that are not prone to erosion. Keep gates shut to avoid stock tracks forming near them - this results in the development of bare ground.
- Leave a reasonable pasture or stubble cover on paddocks during the summer-autumn thunderstorm period. Maintain a mixture of grasses and clover for soil binding properties.
- Don't put out a feed trail for sheep in a downhill direction on soils that are easily eroded.
- Don't drive around wet and boggy paddocks with wheeled vehicles. Post-emergent weed spraying is a particular problem; use pre-seeding residual herbicides, for example Glean®, to reduce this problem.
- Build your own hose-level to survey contour banks. A hose level is quite accurate and is almost as quick to use as a dumpy level.

Wind erosion

- Don't overgraze dry pastures or stubbles - leave 100 anchored wheat stalks per square metre.
- Use minimum tillage or direct-drilling on paddocks that tend to blow.
- Use adequate seed and fertilizer rates to ensure rapid crop establishment, giving ground cover.
- Retain some stubble when double-cropping light soils; otherwise adopt rotations that avoid stubble burning. If you must burn, do so in late March or later.
- Don't harvest clover on large, exposed areas of land prone to wind erosion. Rough-cultivate harvested areas.

Saltland

- Control grazing to maintain a dense vegetation cover. This will reduce capillary rise of water and salt crusting on the soil surface.
- Don't overgraze stands of saltbush, bluebush, samphire or puccinellia. Use this valuable high protein fodder for two to three months in the April-June 'feed gap'.
- Plant a few samphire and bluebush seedlings to colonize fenced saline areas.
- Harvest your own saltbush, bluebush and puccinellia seed. Sow this progressively over your saltland with a combine or preferably a saltbush niche seeder hired from your Land Conservation District Committee.

Continued overleaf...

- Use contour banks and W-drains built with a disc plough or road grader to stop excess water accumulating on saline flats.
- Grow your own tree seedlings and plant them in rows 20 to 30 m apart on mildly affected land to lower saline water tables.
- Budget saltland treatment costs carefully. Relate costs to the value of non-saline land in your district. Talk to your farm management consultant before embarking on expensive programmes.

Trees

- Avoid damaging or destroying trees and natural bush on your farm, along public roads and on public reserves.
- Replace any trees that die or are knocked down. Usually plant two for each tree lost.
- As far as possible use local tree and shrub species. Collect your own seed and grow your own tree seedlings. It is easy and many people do it.
- Avoid damage to trees when burning stubbles or spraying crops.
- Develop a long-term tree planting programme and replant a 'manageable' number of trees *every* year. Plant trees on all non-agricultural areas.
- Protection of existing areas of native bush is cheaper than establishing new plantations. Natural seed dispersal and regeneration costs nothing.
- Plant some trees of a commercial value for example for fence posts, woodchips, or milling timber.

Water supplies

- Test bore new dam sites to reduce the risk of failure by leaky soils, salinity or shallow rock.
- Moderately-sized dams plus good roaded catchments are cheaper and more reliable than big key dams.
- Don't site dams on major creeks where pollution is a problem or low in the landscape where salinity is a greater risk.
- Avoid siting dams near mallet hills and breakaways where leaky soils are common.
- Provide at least 1 m of freeboard to prevent overtopping and wall breaching.
- Provide a grass spillway on one or both sides of the dam wall to allow safe overflow. Don't cultivate too close to dam overflow points.
- Maintain existing boreholes so they are ready to use during droughts and so reduce water carting costs.
- Clean out dams regularly to maintain depth and capacity. Prevent inflows of silt and organic matter with walls, inlet pipes and silt traps in the dam mouth.
- Increase the catchment area to all dams with plough-built contour banks or road-grader built reverse bank seepage interceptors.
- Spray weeds on roaded catchments with herbicides left over from crop spraying.

Waterlogging

- Avoid cropping frequently waterlogged parts of paddocks.
- As fences become due for renewal, progressively separate waterlogged land from well drained land.
- Some frequently waterlogged, sloping land warrants treatment with reverse bank seepage interceptor drains, especially if cropped every second or third year.

The cost of grader-built banks can be recovered in one year by increases in crop yield that average 1 t per hectare.

- Waterlogged flat land can be effectively drained by using shallow W-drains, V-drains or spoon drains.

Off-farm conservation problems

- Stockpile topsoil in gravel pits, and after gravel extraction, rip subsoil, respread the topsoil and reseed or plant native vegetation.
- Use a boring plant when looking for gravel pit sites to avoid unsightly trial pits that have been bulldozed.
- Don't remove vegetation unless absolutely necessary. If it is necessary, replant or regenerate vegetation on reclaimed land, using the vegetation found naturally on that soil type.
- Eliminate roadside and railway burns as much as possible by planting green belts of vegetation. Remember burning increases the wild oat problem.
- Don't use road and railway reserves as sites for your property's firebreaks.
- Don't dump your rubbish on private reserves.
- Don't dispose of your empty chemical containers in a way that could cause damage to humans, animals or the environment.
- Don't discharge your contour banks directly into road reserves.
- Avoid grading drains that have a stable but minimal vegetative cover.
- Use spur drains to control erosion in roadside drains.
- Try to use run-off from roads to fill farm dams.

Acknowledgements

The author is grateful for ideas and assistance provided by members of the Wickepin and Pingelly Land Conservation District Committees.

Further information

- Contact your local Land Conservation District Committee.
- Contact your local Department of Agriculture office for Farmnotes detailing subject areas mentioned in this Farmnote.

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87/88

Western Australian Department of Agriculture

Agdex 570
Soil conservation

Taxation and soil conservation

By Graeme Robertson, Commissioner of Soil Conservation

The Income Tax Assessment Act provides concessions for primary producers that allow expenditure on measures to combat land degradation to be fully deductible in the year incurred.

This Farmnote indicates the ranges of activities that are deductible.

Types of expenditure

Expenditure for preventing or combatting land degradation is usually either of an operating or a capital nature.

Operating expenses such as fertilizer (eg. gypsum on soils with degraded structures) are normally fully deductible in the year incurred whether they are associated with land degradation or not.

Capital expenditure for normal business operations is usually only deductible over longer periods. Where capital expenditure is specifically to prevent or combat land degradation it is fully deductible in the year incurred.

What is land degradation?

Land degradation is any process that makes the land less useful.

Under Western Australian legislation it includes wind and water erosion, salinity, flooding and the removal or deterioration of natural or introduced vegetation.

Other processes such as soil structure decline, soil acidity, waterlogging, non-wetting and compaction of soil all contribute to land degradation.

What is deductible?

Expenditure of a capital nature, not including plant, incurred in an operation primarily and principally for the purpose of preventing or combating land degradation is fully deductible in the year incurred.

The following would be included:

- Establishing or re-establishing plant cover on eroded areas.
- Earthworks such as banks and drains to reduce water erosion.
- Fencing out wind eroded areas to exclude stock.
- Dams constructed for the primary purpose of flood mitigation or reducing water erosion.
- Fencing to exclude stock from saline degraded or fragile areas.
- Fencing to exclude stock from recharge areas where tree planting or special agronomic practices are to be implemented to reduce salinity.
- Re-aligning fences to avoid or overcome land degradation where exclusion of stock is central to the solution.
- Drainage to reduce waterlogging.
- Deep drainage to alleviate soil salinity.
- Culverts and earthworks associated with surface drainage for salinity or waterlogging control.
- A range of activities associated with tree planting (see below).

Trees and land degradation

Trees and shrubs are an important component of many procedures for ameliorating and preventing land degradation and hence in most cases expenditure associated with tree planting would be deductible.

The following types of activities are fully deductible.

- Trees planted in association with water erosion control programmes such as trees on contours, trees in and around active 'gullies'.
- Trees planted as wind breaks. Most soils in Western Australia are at risk to wind erosion and windbreaks should be one strategy used to reduce the problem.
- Trees for salinity control. The hydrology of the majority of the south west of Western Australia is associated with salinity. In most areas each tree established increases water use and contributes to reducing the salinity problem. Planting of trees on saline areas also would be included.
- Regeneration of native vegetation. The decline of native vegetation is an important aspect of land degradation and expenditure on regenerating and managing areas of native vegetation would be deductible.

In the above situations expenditure associated with the establishment, management and protection of trees would be eligible expenditure.

Hence where trees are planted or vegetation is managed to prevent salinity or other forms of land degradation and where the exclusion of livestock is essential to this management, the cost of fencing would be deductible in the year of expenditure.

Taxation and Land Conservation Districts activities

Some primary industry producers have been concerned at possible effects of Fringe Benefit Tax (FBT) on activities associated with Land Conservation District activities.

No FBT liability could arise in relation to such activities unless the person in question is an employee, and benefits (presumably travel, accommodation, use of car, meals etc.) are provided by the employer or by arrangement with the employer.

Thus a self-employed farmer attending meetings, workshops or field days organized by a voluntary soil conservation group could not incur FBT liability in respect of that attendance.

Even if, however, the person attending such meetings is an employee (eg. of a family primary production company or larger pastoral concern), that attendance would generally be seen as having a direct connection with the business operations of the employer.

Soil conservation planning and implementation on a district or catchment basis by primary producers is a business, not a private, activity.

Under the FBT law, the general rule is that the taxable value of a benefit provided to an employee is reducible to the extent that the employee would have been entitled to an income tax deduction if he or she had incurred the expense of providing it.

Continued overleaf...

Farmnote
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Western Australian Department of Agriculture

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Continued overleaf...

An employee of a primary producer who incurs expenditure in travelling to an attending bona fide soil conservation meetings, workshops or field days etc. would be entitled to an income tax deduction in respect of that expenditure if not reimbursed by the employer.

It follows that if the employer incurs the costs, or reimburses the employee, no fringe benefits tax liability will arise.

Conclusion

Land degradation is a major environmental and economic problem in Australia. The Federal Government has recognized this and provided a range of concessions under the Income Tax Assessment Act designed to encourage primary producers to implement practices to prevent or combat land degradation.

Footnote:

At the time of printing (April 1988) the above is believed to be the current interpretation of the Deputy Commissioner of Taxation in Western Australia. However, the Deputy Commissioner's interpretation may change with circumstances and the above does not restrict or limit his interpretation.

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Farmnote
44/90
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Western Australian Department of Agriculture

Agdex 578
Land, legal aspects

Land clearing regulations

By Roger Hartley, Deputy Commissioner of Soil Conservation, Western Australian Department of Agriculture

Regulations gazetted on January 10, 1986 under the Soil and Land Conservation Act 1945-88 require land-users to notify the Commission of Soil Conservation of an intention to clear native vegetation from any area of land larger than one hectare. Notice must be given by the land-user 90 days before the proposed clearing.

The Regulations requiring notification of intended clearing do not apply where land is already controlled under the Country Areas Water Supply Act 1947.

Areas covered by that Act are:

- Wellington catchment area
- Denmark River catchment area
- Kent River water reserve
- Warren River water reserve
- Mundaring catchment area

Purpose

The purpose of these land clearing regulations is to:

- evaluate the capability of land for its intended use before clearing
- ensure that clearing and future use cause minimum land degradation

The regulations are not intended to limit the clearing of land with agricultural potential, but are designed to identify and prevent clearing that may cause land degradation.

Operation

1. Landowners or land-users wishing to clear more than one hectare of land should notify the Commissioner of Soil Conservation. The application can be made to the nearest Department of Agriculture office. Each application should comprise:

- A Standard Notice of Intention to Clear Land (forms available from Department of Agriculture district offices and most Shire offices)
- A plan of the land (see Figure 1) showing location number(s), adjoining roads and indicating:

-areas of the location number or lot number already cleared

-areas of the location number or lot number to be cleared

-areas of location number or lot number that will most likely never be cleared

-soil type and vegetation type of land to be cleared

-intended land use

2. The Commissioner of Soil Conservation will arrange for the land to be inspected, usually within 30 days, but certainly within 90 days. The inspection by a Department of Agriculture officer and if possible, a representative of a local Land Conservation District Committee, will help identify potential land degradation hazards and therefore land that is not suited for clearing.

3. If the inspection indicates that only suitable land has been identified for clearing, the Commissioner will notify the land-user that there are no reasons to restrict clearing.

4. If there are areas where a land degradation hazard will result from clearing, and the land-user agrees to reserve these areas, the land-user will enter a Voluntary Reserve Agreement to preserve the vegetation.

5. The Commissioner will issue a Soil Conservation Notice if the land-user does not accept the need to preserve areas where a land degradation hazard will result from clearing, or where there is a need to specify conditions under which clearing and future land use can proceed.

Restrictions to clearing

Clearing will generally be restricted in the following situations:

- deep sandy soils where clearing results in a wind erosion hazard
- areas designated for wind breaks on soils where wind erosion is likely
- land identified as a groundwater recharge area where clearing is likely to cause a significant rise of the watertable in waterlogged or saline hazard areas
- areas of salinity hazard
- steep slopes where a water erosion hazard is likely
- areas of shallow soil over-lying rock or laterite
- areas required for waterways
- areas adjacent to rivers, creeks, lakes and inlets.

Right of appeal

Any landowner or land-user issued with a Soil Conservation Notice has the right to appeal to the Minister for Agriculture within 30 days of the Notice being served.

The Minister will refer the appeal to an Advisory Committee on Appeals before making a final decision. The Advisory Committee will consider the Notice and the substance of the appeal and will advise the Minister accordingly.

Compensation

No compensation is paid for areas affected by a Notice as the aim of these regulations is to prevent the clearing of land that is likely to degrade and is therefore unsuitable for a desired use.

Penalties

The penalty for:

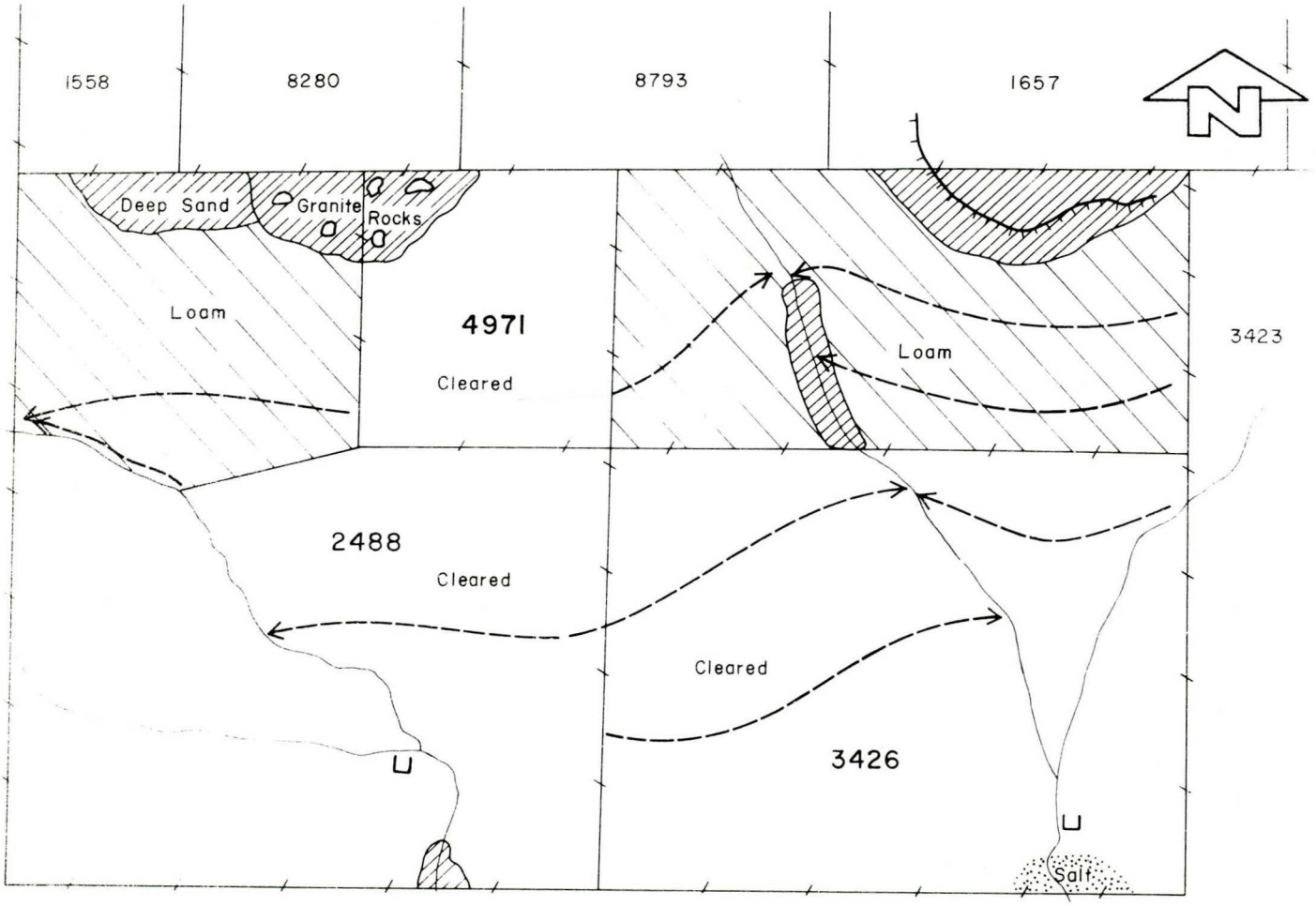
- not giving notice of intention to clear land is a fine of $500
- not abiding by a Soil Conservation Notice is a fine of $2,000

If land is cleared contrary to the directions of a Soil Conservation Notice, the Commissioner of Soil Conservation may demand restoration of the vegetation and the offence can be recurring until the vegetation is restored. The Commissioner may also arrange for restoration work to be carried out and the cost of this work debited against the property title.

For further information

Contact:
The Commissioner of Soil Conservation
Department of Agriculture
Baron-Hay Court
SOUTH PERTH WA 6151
or any district office of the Department of Agriculture.

Fig. 1—Sample plan to accompany standard Notice of Intention to Clear Land for proposed clearing on Avon Locations 2488, 4971 and 3426.



SCALE 1 : 15,000

LEGEND

Waterlogged areas	W	Water Tank		Existing Fence	Ridge
Land Class Boundary	V	Water Trough	trough	Proposed Fence	Breakaway
Windbreak	windbreak	Farm Buildings		Existing Grade Bank	Paddocks No 12
Existing Dam		Stock Yards		Proposed Grade Bank	
Proposed Dam		Farm Roads		Existing Contour Bank	
Roaded Catchment		Active Erosion	E	Proposed Contour Bank	
Bore / Well		To be left uncleared		Gully Fill	
Windmill		To be cleared		Waterway	
				Minor Drainage Line	

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Farmnote
No 33/84

Western Australian Department of Agriculture

Agdex 512

Saltland management—the catchment approach

By R. A. Nulsen, Principal Research Officer, Division of Resource Management

Removal of native vegetation and its replacement by annual crops and pastures has long been know to induce soil salinity in the agricultural areas of Western Australia. The increased soil salinity due to man's intervention is known as "secondary salinity" and it has degraded large areas of once productive agricultural land and made many of the major rivers in the south-west of the State unusable for irrigation and industry.

Water is the real problem

When land is developed for agriculture a number of changes occur in the water balance of the landscape. The unseen change in the water balance after clearing is the decrease in plant water use and increase in the amount of water draining deep into the soil beyond the plant root zone. The extra quantity of water moving as deep drainage is small (20 to 80 mm/year) but it is this water that dissolves the salts stored in the landscape, causes a rise in the deep water-table and eventually causes the salinity problem. A more obvious change in the water balance after clearing is an increase in surface runoff. This is accompanied by an increase in shallow sub-surface seepage and the two processes can cause severe waterlogging problems in the valley floor.

Water flows in the landscape can be considered as two systems—a shallow system (surface runoff and shallow sub-surface seepage) and a deep system (deep drainage). The shallow system contains most of the water but is very low in salt; the deep system has relatively little water but has a high salt content. This is shown schematically in Figure 1.

Both systems must be managed to control the salinity problem. It is possible to manage both water systems and the management methods are not necessarily complex or expensive. However, effective management requires an understanding of the processes occurring and an understanding of where in the landscape these processes operate.

Problem definition

Before any management strategies can be effectively applied, the problem must be properly defined. Different strategies will be required if, for example, the problem is essentially a waterlogging problem than if it is caused by saline groundwater being forced towards the surface by a clay or rock bar. Problem definition requires an understanding of the waterflows in the landscape surrounding the saline area. Considerable investigation and observation is frequently necessary.

The importance of catchment management

Appropriate management of saltland depends on the climate, hydrology, soils and economics pertinent to the specific piece of land. The management objective can either be to produce food, fuel or forage from the saltland, or to reclaim the saltland to allow production of non salt tolerant species. In most situations reclamation is a slow process and some form of production from the saline land should be an interim objective.

To obtain production from saltland it is necessary to improve both the physical and chemical conditions of the soil to permit plant growth. The improvements necessary can rarely be achieved simply by working on the salt affected area itself. It is often necessary to modify the land use on the catchment area above the saltland. Remember that the two water systems causing the problem originate some distance from the saltland. Thus the problem of management of salt affected land becomes one of catchment management, requiring manipulation of the environment of an area many times the size of the affected land.

Management options

Management must be considered in terms of what can be done on the catchment area above the saltland (off-site) and what can be done on the saltland itself (on-site). However, off-site and on-site management strategies are linked and a combination of both is necessary for effective control.

On-site management	Off-site management
1. Surface and/or sub-surface drainage of the salt affected area.	4. Surface water management on the catchment slopes.
2. Prevent surface water flow onto the salt affected area.	5. Implement high water use options of broad recharge areas—species, tillage and fertility.
3. Production from the salt affected area with salt tolerant shrubs or grasses.	6. Treatment of specific recharge areas with trees and shrubs.

The above is a convenient way of thinking about catchment management. Another way of looking at it is that water should be removed from the saltland while at the same time flow of water to the saltland should be prevented. When these water flows have been controlled it is then the proper time to attempt growing plants on the area.

On-site management

The aim of on-site management is to improve conditions for growth of both salt tolerant and non salt tolerant plants by reducing waterlogging and increasing leaching of salts down through the soil profile.

1. *Surface and sub-surface drainage*

Surface drainage (W drains, spoon drains etc.) reduces surface flooding and waterlogging and can often improve conditions sufficiently to allow the area to be worked and to permit growth of plants.

The aim of sub-surface drainage is to reduce the level of the water-table to below a "critical" depth which ensures that the net movement of salts is downwards. Salts are thus prevented from accumulating in the root zone. The critical depth depends on soil type and climate but is generally between 1.5 and 2 metres. Even after the water-table level has been reduced it can take some years for the soil to be leached of sufficient salt to allow growth of normal agricultural crops.

Continued overleaf

2. *Prevent surface water flow onto the salt affected area*

Waterlogging can be reduced by re-directing run-off water into natural or prepared waterways. Both surface flow and shallow sub-surface flow should be intercepted and disposed of safely and legally.

This ensures that the drains on the saltland only have to cope with the water in their immediate surrounds and not with the large quantities of water coming from the rest of the catchment.

Since this measure is most effectively implemented close to the boundary between the saltland and the fresh ground, it is arguable whether it is on-site or off-site. It is considered on-site here because in many cases this measure, in conjunction with (1) will result in very substantial improvement in the ability of the saltland to grow plants.

3. *Production from the salt affected area with salt tolerant shrubs or grasses*

Much of our saltland will remain saline for many years despite drainage and catchment treatments. This is because of the high salt levels in the soil and the low leaching rate attained with our soil and rainfall conditions. However, this land can be made productive by sowing to salt tolerant shrubs (such as bluebush and saltbush) or grasses (such as Puccinellia and wheatgrass). The resulting pastures can be grazed in the autumn-early winter period and thus make a positive contribution to the farm economy.

Off-site management

The aim of off-site management is to prevent water, and the salts it transports, moving to the salt affected area. Management strategies are aimed at controlling the surface and shallow sub-surface waters with banks and at reducing the input to the deep groundwater system by growing plants with higher water use characteristics on recharge areas of the catchment.

4. *Surface water management on the catchment slopes*

The aim of both run-off and shallow seepage control is to ensure an even distribution of water on the slopes.

Surface run-off and shallow sub-surface flow of water occurs within a catchment after most rainfall events. Excessive collection of water at any point can lead to waterlogging which can severely reduce crop yield. Excessive run-off can also cause severe soil erosion.

Run-off and sub-surface seepage can be controlled most effectively by earthworks of various kinds and by tillage techniques such as minimum cultivation and deep ripping. The type of earthwork to be used, or the tillage technique most appropriate, depends on soil type, slope and position in the landscape.

If the major problem is correctly identified as primarily a waterlogging problem then strategies 1, 2 and 4 can improve conditions enough to obtain good crop yields.

However, if there is an associated salinity problem then strategies 5 and 6 must also be implemented to get some control of the deep groundwater system.

5. *High water use options on broad recharge areas*

Excess water which is not used by the plants may penetrate beyond the root zone and raise groundwater levels; this is known as "recharge".

Many options are available for reducing recharge by changing land use. The most obvious is to return the land to its original vegetation. This would rarely be economic except when the salinity problem places a valuable public resource at risk. Such is the case in the south-west of Western Australia where salinity threatens the quality of stored waters which are used for irrigation, industry and human consumption.

It is difficult to identify recharge areas without substantial field investigation, but in general sandy or gravelly soils high in the catchment will contribute more water to recharge than will areas of clay type soils.

Measurements of crop water use in Western Australia have shown that, for instance, lupins use more water than sub. clover; that on some soil types deep ripping increases plant water use and that fertiliser rates, particularly nitrogen, affect plant water use.

The appropriate combination of species, tillage and fertilisers will maximise plant water use and minimise recharge.

6. *Treatment of specific recharge areas*

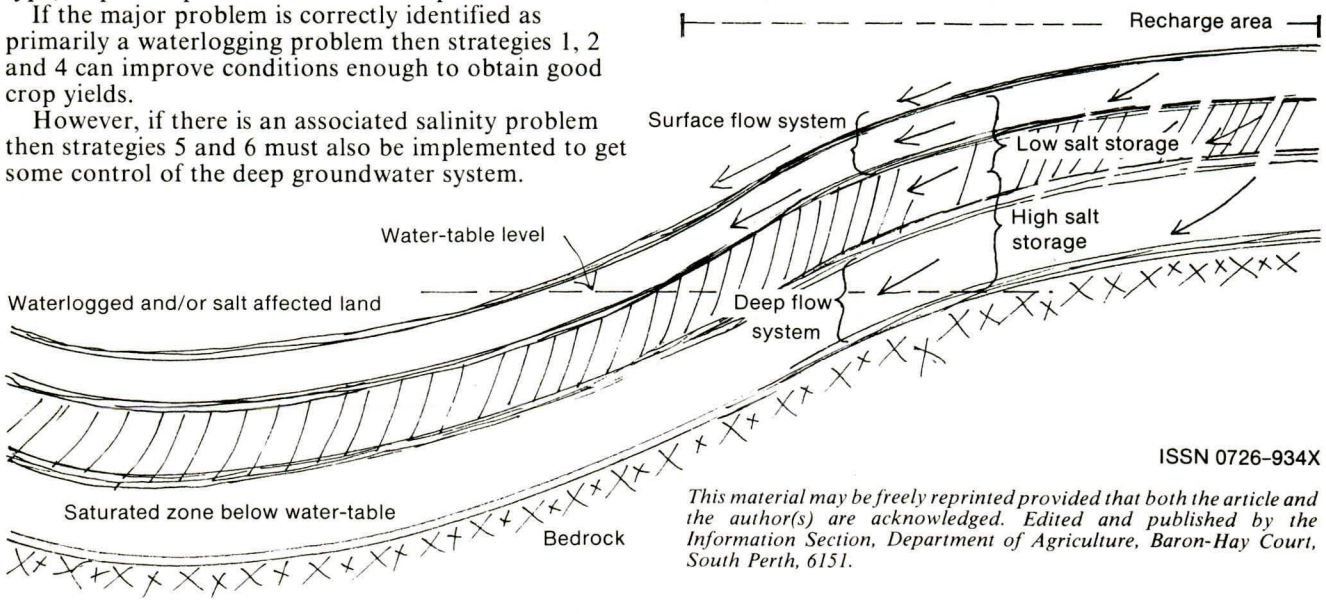
In some landscapes there are small areas (only a few hectares) which, whether under crop or pasture, contribute most of the rain falling on them to recharge. These areas have high infiltration rates and low water storage and usually grow uneconomic crops. Such areas should be planted to deep rooted perennials such as trees. Fodder trees, such as Tagasaste (previously known as tree lucerne), may be appropriate in some areas.

Conclusions

Successful management of saltland requires correct problem definition, management of the catchment water balance and management of the saltland area itself. The object of any management programme should be defined, but ideally should be to contain and if possible reclaim the saltland, and obtain production from the saltland itself.

No adequate management strategy can be applied unless the factors causing the saltland are at least qualitatively understood—quantification of these factors will result in more efficient and more effective management. Once the problem and management objectives have been defined, a combination of the appropriate strategies can be applied.

Figure 1. Schematic diagram of catchment cross-section showing water flow pathways.



ISSN 0726-934X

Farmnote
No. 44/86

Western Australian Department of Agriculture

Agdex 330/10

Saltland management-revegetation

By Clive Malcolm, Principal Research Officer, Division of Resource Management

The aim of saltland management is to make saltland productive.

There are three main aspects to saltland management and they are complementary. Two aspects, *catchment management* and *water control* are discussed in Farmnote No. 133/84. This Farmnote deals with the third aspect, *revegetation* of saltland. All three aspects are important to ensure the best revegetation results.

There is more detailed information on selecting plants for saline areas in Farmnote No. 32/86.

Revegetation may be achieved by either of three alternative strategies—low cost revegetation, comprehensive revegetation and prescription revegetation.

Low cost revegetation

Farmers have demonstrated that saltland can be revegetated with useful forage shrubs at very low cost. Thousands of hectares are grazed every year as an autumn fodder reserve because farmers have adopted the low cost revegetation strategy.

This strategy involves five steps:

Step 1: Exclude sheep from the paddock to be treated.

Step 2: Introduce bluebush and samphire seed.

Step 3: Crop non-saline areas of the paddock.

Step 4: Cultivate bare, crusted areas in autumn.

Step 5: Graze carefully from about March to May.

Repeat all five steps every year, with the cropping programme on non-saline areas designed to maintain soil productivity—a wheat/seed legume rotation may be appropriate.

1. *Exclude sheep*

Sheep must be excluded, from about June to February each year, so shrubs become established and grow to their mature size. In paddocks with a high proportion of saltland, fencing can be avoided by cropping the non-saline areas so that production is not lost. If fencing to exclude stock is essential, it can be done as part of a farm refencing programme. Also, the use of electric fencing can reduce costs.

2. *Introduce bluebush and samphire*

The low cost revegetation strategy is based on the ability of bluebush and samphire to colonise saltland easily. Several bushes of each, with correct management, will produce a dense stand in a few years.

Bluebush may be introduced by collecting its seeds in autumn (see Farmnote No. 44/83) and spreading them on the surface of cultivated ground. As bluebush will not grow on waterlogged soils, introduce samphire to these areas (see Farmnote No. 4/82).

3. *Crop non-saline areas*

By cropping the non-saline areas of a paddock, the saline areas will be protected from grazing during crop growth and harvest. Extend cropping, possibly with barley, into areas of uncertain potential as this helps to identify the boundaries between arable use and shrub pasture. Use a crop rotation that conserves soil productivity.

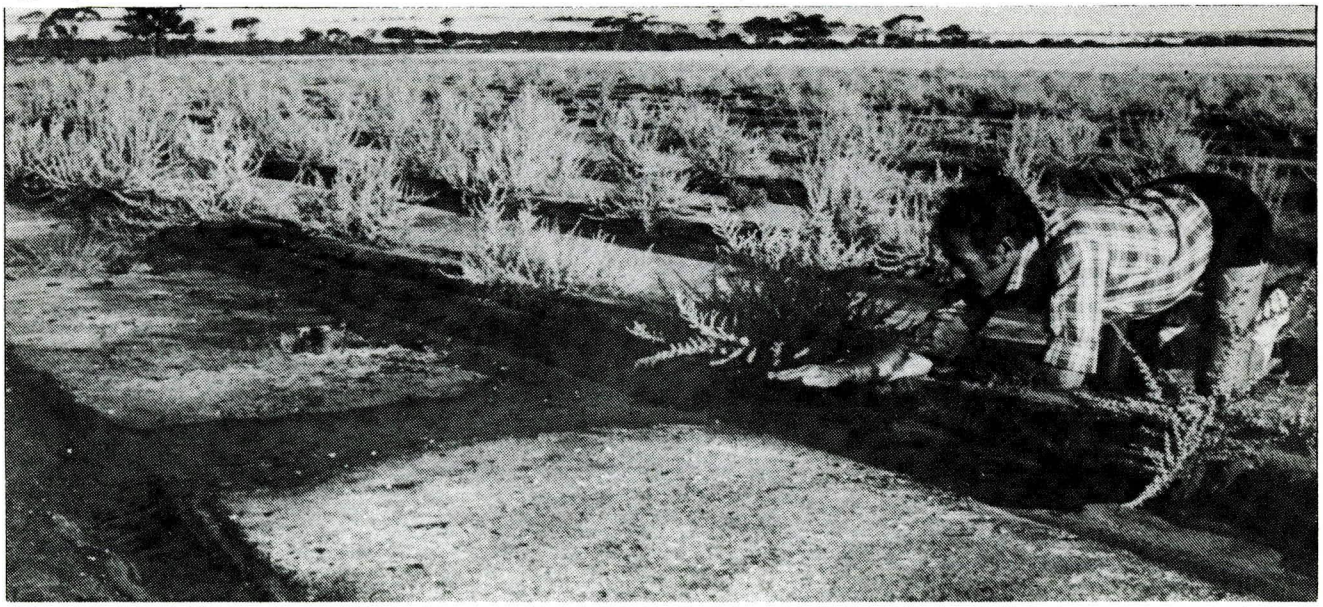


Fig. 1—Wavy leaf saltbush, 8 months old, established by niche seeding east of Wongan Hills. The raised niche enabled establishment despite winter waterlogging.

Continued overleaf

4. *Cultivate bare areas*

Cultivate bare areas, especially if they are crusted, to trap blowing seed, and increase rainfall penetration so that salt can be leached from the soil surface. Use a cheap method such as a chisel plough with wide tine spacing (about 60 centimetres) and 5 to 10 centimetre penetration. Cultivate in summer or autumn especially in areas where seeds are being shed.

5. *Graze carefully*

Graze carefully during March to May after the bluebush and samphire seed has matured on the plants and bare areas have been cultivated. If the bluebush and saltbush are colonising slowly it is worthwhile not to graze the paddock at all even if stubble and other feed is wasted. In the early years of shrub establishment grazing should be stopped before young plants are killed.

Most saline areas in districts receiving, on average less than 375 millimetres of rain a year will develop a dense stand of shrubs in 5 to 10 years using the low cost revegetation strategy. Once fully revegetated, saltland will support sheep at 500 to 2,000 sheep grazing days per hectare every autumn depending on the shrub species, rainfall and severity of salting.

Comprehensive revegetation

The severity of saltland is highly variable. Few areas are suited to treatment with a single plant species, and the zones of different severity are usually intermixed, making separate sowing difficult. Comprehensive revegetation uses selective sowing and seed mixtures to get a rapid, productive and well adapted cover.

This strategy involves six steps:

Step 1: Mark areas suited for bluebush, saltbushes and samphire.

Step 2: Prepare for seeding.

Step 3: Exclude stock.

Step 4: Sow samphire and Puccinellia.

Step 5: Niche-seed bluebush and saltbushes.

Step 6: Do not graze for 22 months.

1. *Mark areas suited for bluebush, saltbushes and samphire*

The conditions to which various salt tolerant forages are adapted is described in Farmnote No. 32/86. Selection of species is strongly influenced by the degree of waterlogging at the site and allowance should be made for any reduction in waterlogging from the *catchment management* and *water control* phases of saltland management.

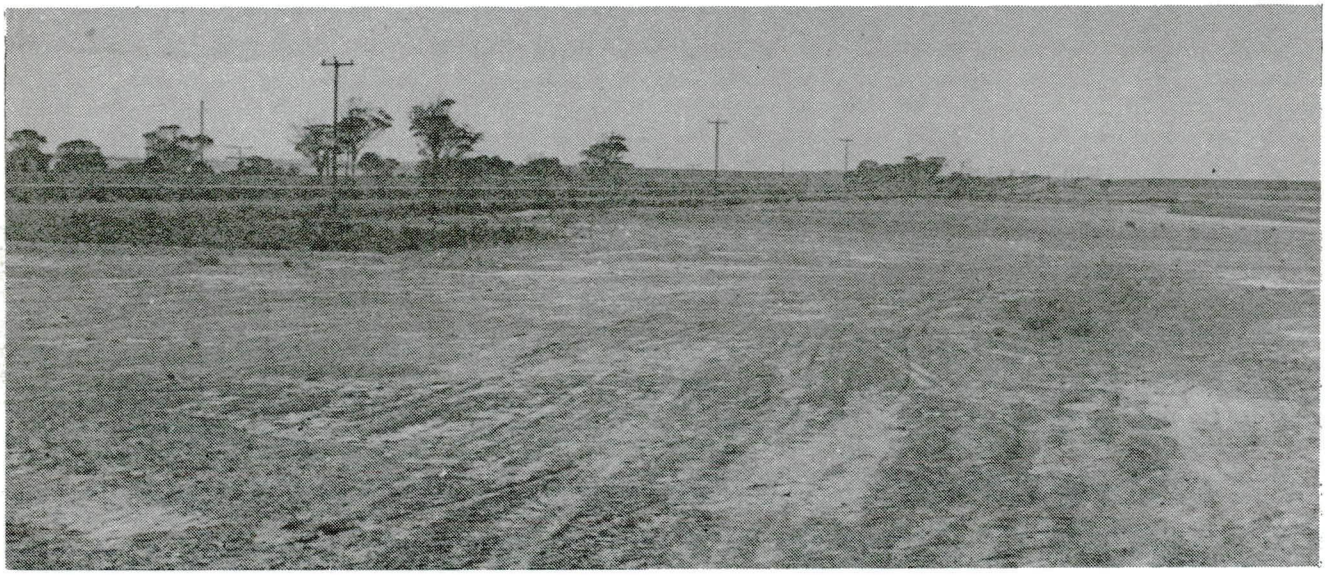


Fig. 2a—Severely saline and waterlogged land east of Cunderdin. Note the small fenced area of samphire near the road.

Fig. 2b—The same area as in (a), but five years later. The only treatment has been complete protection from grazing. The area at extreme right was sown with saltbushes and bluebush.

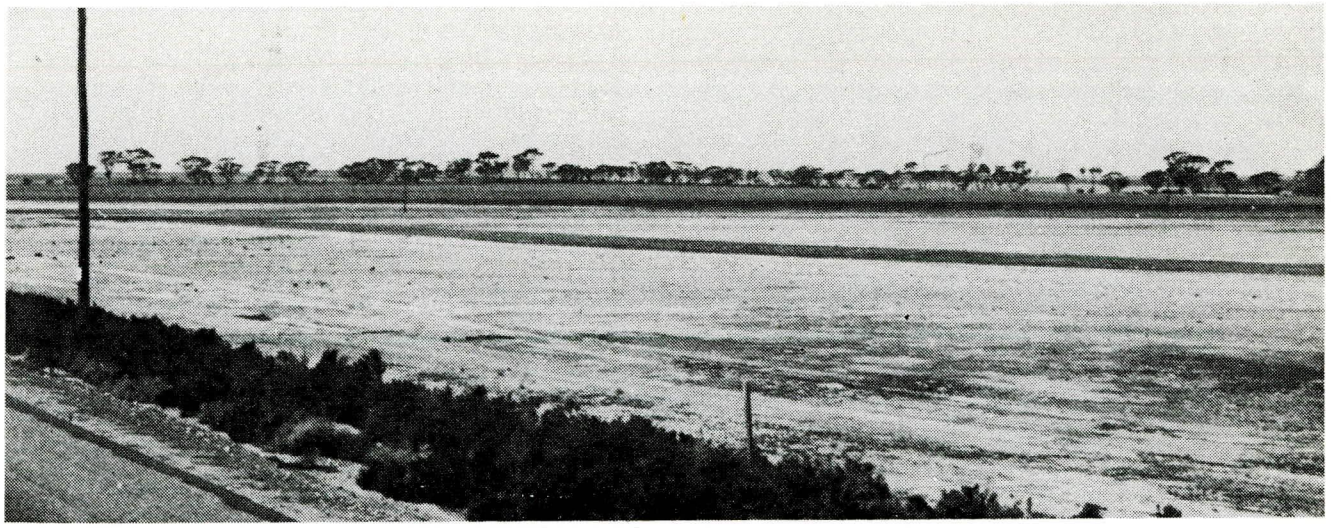


Fig. 3a—Severely saline and waterlogged land east of Cunderdin.

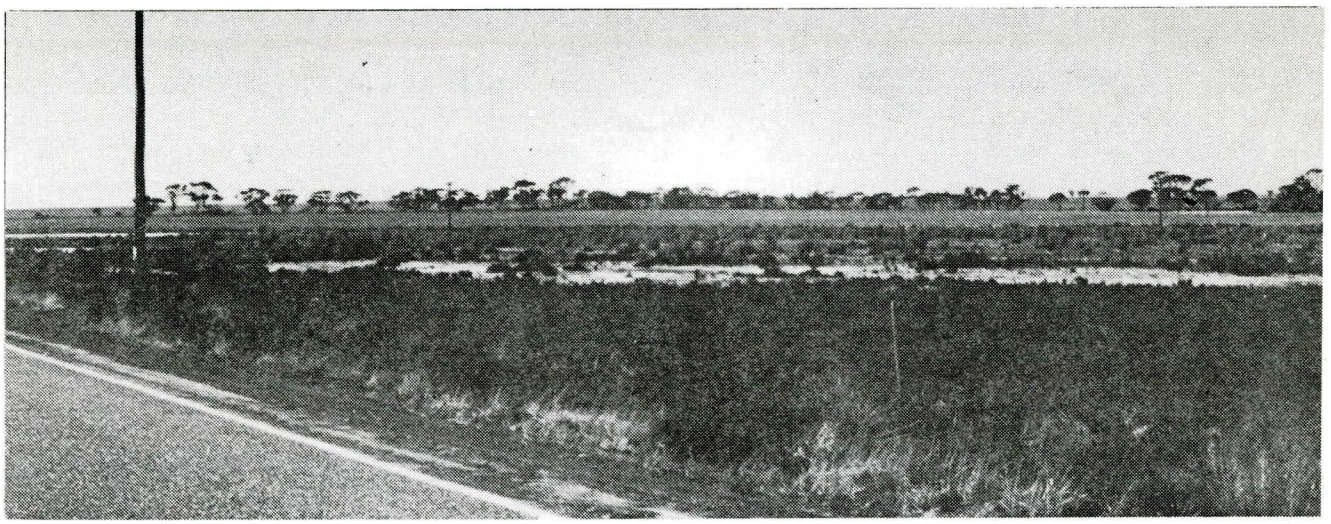


Fig. 3b—The same area as in (a), but five years later. The dark section in the foreground was protected from grazing and has covered with samphire. The area in the background was sown to saltbushes and bluebush.

2. *Prepare for seeding*

Clean up the site. This may involve installing banks or drains for water control and grazing to remove dry feed. The area should then be cultivated, before the opening rain, to assist water infiltration and leaching of salt. Using a scarifier or chisel plough that penetrates the soil 5 to 7 centimetres, is adequate.

3. *Exclude stock*

It may be possible to avoid fencing costs by cropping non-saline areas: otherwise fence off saline areas and keep stock out.

4. *Sow samphire and Puccinellia*

Seed collection and sowing instructions for samphire are in Farmnote No. 4/82. The samphire may be sown before the opening rain at the same time as the initial cultivation.

Recommendations for sowing Puccinellia are in Farmnote No. 34/82. In the comprehensive revegetation strategy, Puccinellia is included as an understorey for the shrubs as it has shown as ability to grow beneath and between bushes of bluebush, saltbush and samphire on a range of sites in the wheatbelt. Puccinellia may be sown over the whole area, or in strips to reduce cost, or mainly in those areas where saltbushes are sown.

5. *Niche-seed bluebush and saltbushes*

Recommendations for sowing bluebush, wavy leaf saltbush and river saltbush are in Farmnote No. 43/83. In the comprehensive revegetation strategy it is recommended that a mixture of species be sown at a spacing of 3 metres x 2 metres after the Puccinellia has been sown. This mixture of species should be sown using the Mallen Niche Seeder. The seed mixture could include bluebush (0.5 kg/ha), wavy leaf saltbush (1.0 kg/ha), river saltbush (0.5 kg/ha) and quail brush (0.5 kg/ha). On saltland especially suited to bluebush sow more bluebush at the expense of the others. If the site is suited more to saltbush, then sow more saltbush and less bluebush. Vermiculite should be used as a mulch at seeding. Establishment is improved by applying black latex paint (see Farmnote No. 43/83) but at present the cost is prohibitive (about $100 per hectare).

6. *Do not graze for 22 months*

It is essential to allow planted species to become established. Bluebush usually produces seed in the first year and within 22 months of sowing will have produced many new plants.

Seeds of saltbushes and samphire remain viable in the field for at least one year. Saltbush seeds can germinate in the first or second winter after sowing and after summer rain. The success of a planting cannot be judged until at least 22 months after sowing. Under favourable conditions, a uniform, well grown stand may be produced within 12 months of sowing and can be grazed moderately. The branches of wavy leaf and river saltbushes often lie on the ground and produce roots in the second winter after sowing. Grazing may reduce this 'stem rooting'.

Continued overleaf

Fig. 4—River saltbush, about 9 months old, established in highly saline soil south of Tammin by niche seeding.

Prescription revegetation

Various alternatives to the *low cost* and *comprehensive* revegetation strategies may be worked out for specific paddocks and economic circumstances.

Prescriptions for particular situations may include the following techniques:

- Increase the spacing between shrub rows to reduce cost; this method relies on correct grazing management to encourage colonisation.
- Omit seeds of species such as bluebush and river saltbush which are expensive and in short supply.
- Omit seeds of bluebush and samphire if they are already growing nearby.
- Omit Puccinellia and introduce it later if desired.
- Use small amounts of bluebush and samphire seed to introduce them to an area.
- Sow some pure stands for seed harvesting. It is important to keep different saltbush species separate for seed production to ensure cross-pollination does not occur.

Further reading

- Farmnote No. 23/80—'Salt-water couch—for salty seepages and lawns' (Agdex 333/20).
- Farmnote No. 4/82—'Samphire for waterlogged saltland' (Agdex 332/512).
- Farmnote No. 34/82—'Puccinellia—its grazing value and management' (Agdex 333/10).
- Farmnote No. 44/83—'Collecting and treating bluebush seed' (Agdex 332/20).
- Farmnote No. 133/84—'Saltland management—the catchment approach' (Agdex 512).
- Farmnote No. 83/85—'Spray.Seed® for Puccinellia establishment (Agdex 333/21).
- Farmnote No. 32/86—'Saltland management—selecting forage plants for saltland' (Agdex 330/20).

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Farmnote
Nc /86

Western Australian Department of Agriculture

Agdex 330/20

Saltland management—selecting forage plants for saltland

By C.V. Malcolm, Principal Research Officer, Division of Resource Management

Saltland in the agricultural areas of Western Australia, if sown with suitable plants, will produce feed for stock on a regular basis.

The guidelines in this Farmnote indicate which plants will grow successfully on different types of saltland. To select the best adapted plant for a particular area of saltland refer to Table 1.

Saltland conditions

Factors to consider when deciding on a grazing plant for a particular type of saltland are the severity of salinisation of the site and the degree to which waterlogging or flooding occurs.

Site severity

On most saltland the severity of 'salting' is assessed by observing the species of 'volunteer' plants present and the proportion of the area these plants cover. This plant cover may also be affected by seasonal conditions, cultivation and stock grazing intensity. It is convenient to divide saltland into three categories: mild, moderate and severe.

- On mildly affected saltland the usual plant is Mediterranean barley grass (*Hordeum geniculatum*), often called sea barley grass in Western Australia. Plant species sensitive to salt such as subterranean clover, barrel medic and capeweed are usually absent but annual ryegrass and woolly clover can be present. There may be some plants of sand spurry (*Spergularia rubra*), curly ryegrass (*Pholiurus incurvus*), ice plant (*Mesembryanthemum nodiflorum*), *Plantago* spp. and *Cotula* spp. On mildly salt affected soils, plants usually cover the whole area.
- On moderately affected saltland the plants are usually Mediterranean barley grass, annual ryegrass and woolly clover amongst areas of bare ground.
- On severely affected saltland the only plants present are sand spurry, curly ryegrass, iceplant, samphire, *Plantago* spp. and *Cotula* spp. After grazing by stock these areas are usually completely bare.

If site severity cannot be assessed from the volunteer plant cover, the salt affected areas can be sown to an 'indicator' crop like barley or oats.

- Mild areas may give a profitable return only if seasonal conditions are favourable, that is, a good opening rain for germination, no winter waterlogging and good finishing rains.
- Moderate areas will not give a profitable crop even in favourable seasons.
- Severe areas will not mature a crop at all.

The site severity is usually related to the depth below the soil surface of saline groundwater (watertable). In a sandy soil the groundwater must be much closer to the surface than in a loamy soil to cause the same severity of 'salting'. Typical depths to groundwater for the three classes of saltland severity are:

Severity of saltland	Depth† to saline groundwater
Mild	more than 1.6 m
Moderate	0.8 to 1.8 m
Severe	0 to 1.1 m

† This is only a guide as it varies with season and soil type.

There is some overlap in the depth to saline groundwater between the classes of saltland severity. The depth to saline groundwater can vary between the seasons within the year. On some soil types, for example Morrel, severe salting may occur without any watertable.

Waterlogging and flooding

Saltland sites may be permanently waterlogged due to seepage or seasonally waterlogged (usually in winter) due to shallow groundwater and excess water on the soil surface. Before planting species on saltland, minimise waterlogging by installing surface drains and contouring the catchment above the area.

The severity of waterlogging is best assessed by its duration. Salt tolerant forage plants are rarely killed by 'flash' floods, but when the soil surface is waterlogged for several weeks some species die. Few species survive when waterlogged for several months.

Salt content and pH of soil

To confirm that salt is a problem, take two soil samples, one from 0 to 15 centimetres and one from 15 to 30 centimetres below the soil surface from an area of bare soil during summer. Salinity is confirmed if at least one of the samples has above 0.2 per cent chloride or an electrical conductivity above 140 millisiemens per metre (mS/m) when measured in a 1:5, soil:water suspension. Also check the pH (acidity/alkalinity) of the samples—readings below 5.0 are associated with poor establishment of Puccinellia and poor survival and growth of shrubs.

Since the salt content of soil can vary greatly it is not useful as a guide to species selection. It is best to observe the growth of volunteer or indicator plants as these reflect the combined effects of soil salinity and other factors.

Salt tolerant plants for grazing

- Barley (six-row) will tolerate mild salinity. Areas that no longer grow a profitable barley crop due to salinity may be planted to salt tolerant plants for grazing.
- Paspalum (*Paspalum dilatatum*) is a perennial grass with mild waterlogging and salinity tolerance.
- Strawberry clover (*Trifolium fragiferum*) will tolerate waterlogging and mild salinity. It will grow on the perimeter of relatively fresh seepage areas.
- Tall wheat grass (*Agropyron elongatum*) is a perennial grass of moderate salt and waterlogging tolerance. It grows on the mildly and moderately affected parts of saltland in areas receiving more than 375 mm annual rainfall. It grows best in spring and summer on moisture from groundwater (not too saline) or rainfall.
- Salt water couch (*Paspalum vaginatum*) is a summer growing grass, highly tolerant of salt and continuous

continued overleaf

waterlogging. It grows well in areas permanently wet by seepage but is not suited to salt lakes or samphire flats. It can prevent soil erosion in creeks and on hillside seepages. It may be used as a lawn grass.

- Puccinellia (*Puccinellia ciliata*) is a winter growing perennial, tussock-forming grass highly tolerant of salt and waterlogging. It will grow on all salt affected soils in areas receiving more than 375 mm of annual rainfall. In drier areas its growth is less reliable.
- Bluebush (*Maireana brevifolia*) is a highly salt tolerant perennial shrub. It is sensitive to waterlogging and should not be planted if there is danger of being flooded for more than two to three days.
- Wavy leaf saltbush (*Atriplex undulata*) is a highly salt tolerant perennial shrub. It is moderately tolerant to waterlogging. It will survive several weeks on a flooded site in winter. The branches can form roots where they rest on the ground thus aiding recovery from grazing and control of soil erosion.
- River saltbush (*Atriplex amnicola*) is a highly salt tolerant perennial shrub. It is slightly more waterlogging tolerant than wavy leaf saltbush. The branches form roots readily and recovery from severe grazing is excellent.
- Samphire (*Halosarcia spp*) is represented by several species. All are highly tolerant of salt and waterlogging and will grow to the edges of salt lakes. The plant material has a high salt content but may be grazed by sheep provided other feed such as stubble or dry annual pasture is available.

Establishment period

Even salt tolerant plants are difficult to establish on saltland. Wind erosion, waterlogging, variable seasonal conditions and high soil salinity may combine to cause poor establishment. Take measures to reduce wind erosion and waterlogging before sowing saltland. Plant growth on saltland is often slow in the first year. Ensure that all plants are protected from grazing for at least 20 months after sowing.

For further information or assistance contact the local district office of the Department of Agriculture.

Establishment and management

Details of establishment and management methods for some forage plants are contained in the following Farmnotes:

23/80—'Salt-water couch—for salty seepages and lawns' (Agdex 333/20)
4/82—'Samphire for waterlogged saltland' (Agdex 332/512)
34/82—'Puccinellia—its grazing value and management' (Agdex 333/10)
43/83—'Seeding shrub pastures on saltland' (Agdex 332/21)
44/83—'Collecting and treating bluebush seed' (Agdex 332/20)
133/84—'Saltland management—the catchment approach' (Agdex 512)
31/85—'How to raise saltbush and bluebush seedlings' (Agdex 332/21).
83/85—'Spray.Seed® for Puccinellia establishment' (Agdex 333/21)

Table 1—A guide to selecting salt tolerant forage plants for saltland types in the agricultural areas of Western Australia

Saltland type and conditions			Site severity*		
			Mild	Moderate	Severe
Hillside seepage		Soil surface wet in summer	*Strawberry clover,*** paspalum, couch, kikuyu	*Salt water couch*	*Salt water couch*
		Soil surface dry in summer	*Puccinellia,* barley, tall wheat grass	*Puccinellia*	*Puccinellia*
Saline valley floors	more than 375 mm annual rainfall		*Puccinellia,* barley tall wheat grass	*Puccinellia, saltbushes****	*Samphire*
	less than 375 mm annual rainfall	Commonly flooded	*Saltbushes,* Puccinellia, barley	*Saltbushes,* Puccinellia, samphire	*Samphire*
		Seldom flooded	*Barley,* bluebush, Puccinellia, saltbushes	*Saltbushes,* bluebush, Puccinellia	*Saltbushes,* samphire Puccinellia
Dryland salinity	less than 375 mm annual rainfall	Never flooded	*Barley,* bluebush, saltbushes	*Bluebush,* saltbushes	*Bluebush,* saltbushes

* Site severity is defined in the text.
** The recommended plant is shown in italics, others listed are also capable of reasonable growth.
*** Saltbushes are only recommended in areas with less than 500 mm annual rainfall.

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AUSTRALIAN FODDER SHRUBS SOCIETY

GROWING FODDER SHRUBS ON SALTLAND

WHY GROW SALT FODDER SHRUBS?

Bluebush and saltbushes (Maireana and Atriplex species) are perennials which:

* turn saltland into a highly profitable reserve,
* prevent erosion and help lower watertables,
* provide shelter and feed during the autumn/winter feed gap,
* allow deferred grazing on annual pastures at the break of season,
* support a rich ecosystem on previously bare land.

WHERE CAN I GROW SALT FODDER SHRUBS?

* on saline land in less than 550mm rainfall zones,
* which species you choose depends on the degree of waterlogging.

HOW DO I GROW SALT FODDER SHRUBS?

* direct seed with niche seeding machine, or,
* plant seedlings,
* niche seeding is cheaper but less reliable,
* bluebush and samphire will spread themselves for the cost of grazing protection.

WHAT CAN I DO TO ENSURE A GOOD STAND?

* choose the correct species.

	Annual Plant Cover		
Conditions	Barley Grass	Patchy cover	Bare
Summer wet seepages	Strawberry clover	Salt water couch	Salt water couch
Common flooded	Puccinellia	Puccinellia	Samphire
A few weeks waterlogging per year	River saltbush Wavy leaf saltbush Quail bush	River saltbush Wavy leaf saltbush Quail bush	Samphire
Never waterlogged	Barley	Bluebush	Bluebush

1 **Prepare the site well**

* on and off-site control of water to minimize flooding and waterlogging,
* fencing for stock control,
* weed control by grazing, burning , cultivation and/or spraying,
* survey grade line for sowing,
* pre-cultivate to give a good seed/seedling bed,

  - but don't bog yourself out!

2 **Get good seed/seedlings**

* ask for a germination test,
* allow about 40 good seed per place, or
* use well grown hardened seedlings.

3 **Check out your soil type**

Soil	Method
Depth of sand to loam over clay > 7cm	Niche seed
Depth of sand to loam over clay < 7cm	Plant seedlings
Clay loam (often crusted and slaked)	Plant seedlings
Clay	Plant seedlings

4 **If you're niche seeding**

* rip in the seeding line,
* don't let soil "overhang" the niche,
* lower and widen the niche for dry conditions,
* raise and narrow the niche for wet conditions.

5 **If you're planting seedlings**

* rip in the seeding line,
* plant on a bank in wet areas,
* control weeds.

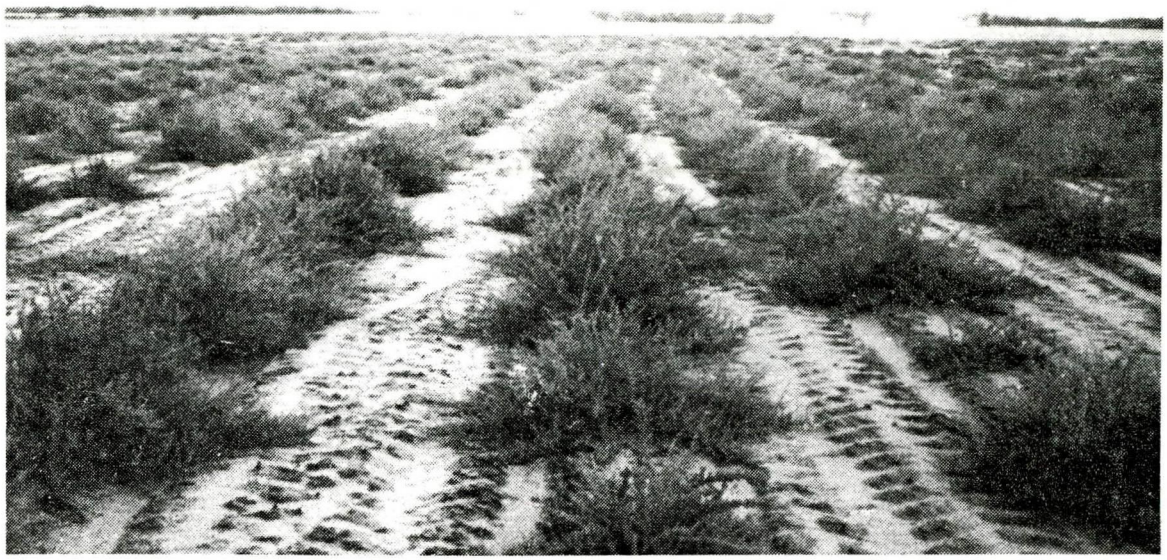
Farmnote
No 3/83

Western Australian Department of Agriculture

Agdex 332/21

Seeding shrub pastures on saltland

By C. V. Malcolm, Senior Research Officer, Division of Resource Management



A year-old stand of wavy leaf saltbush established from seed at Maya in 1981 and using the niche seeding technique.

Three species of salt tolerant shrubs for forage production are recommended for planting on saltland in the Western Australian wheatbelt.

The best way to establish the shrubs is to use the niche seeding technique developed by the Department of Agriculture.

This Farmnote describes the recommended species and the seeding technique.

Bluebush *(Maireana brevifolia)*

This shrub is native to the wheatbelt where it is widespread on salt-affected sites that do not become waterlogged in winter. It is high in protein, recovers well after heavy grazing and spreads quickly by natural seeding from established bushes. Bluebushes vary in size with grazing pressure but may reach 0.9 metres tall and 1.5m wide.

Seeds of bluebush may be collected by shaking the bushes into a bin or bag. The seed ripens during summer and autumn and is usually best collected after a few hot still days in March. Seed must be air-dried thoroughly (for example, on the shearing shed floor) before storage and should be used in the year it is collected. It is also available commercially.

Using the niche seeding technique, seed should be sown at about one kilogram per hectare, covered with vermiculite and sprayed with a slow-setting bitumen emulsion such as Terrolas. A suitable plant spacing is 1.5 to 2m between rows and 1 to 1.5m within rows.

Wavy leaf saltbush *(Atriplex undulata)*

This shrub was introduced to Western Australia from Argentina by the Department of Agriculture. It is a spreading shrub which grows to 2 to 3m in diameter and 0.5m tall under wheatbelt conditions. The prostrate branches form roots which help it recover from hard grazing.

Wavy leaf saltbush has performed well in the salt flats in broad wheatbelt valleys on sand over clay soils that previously carried ti-tree and/or York gum.

Wavy leaf saltbush can be sown by the niche seeding technique with vermiculite and Terrolas or its equivalent. Seed, which is available commercially, should be sown at 2m by 1.5m spacing at about 1kg/ha.

River saltbush *(Atriplex rhagodioides)*

A native to the pastoral areas in the catchments of the Greenough, Murchison and Gascoyne Rivers, river saltbush has grown exceptionally well on salt-affected areas in the wheatbelt and in mixed farming areas. It is a spreading bush which may reach 4m across and a metre tall. The prostrate branches take root and the bushes recover well from heavy grazing.

River saltbush is more difficult to establish than bluebush and wavy leaf saltbush. Sow at a heavier seeding rate (2 to 4kg/ha depending on seed quality) and a closer spacing (2m by 1m) than would otherwise be necessary.

Research on establishment of this species indicates that best results are obtained by covering the seeds with a mulch of vermiculite and spraying a black coating over the placement.

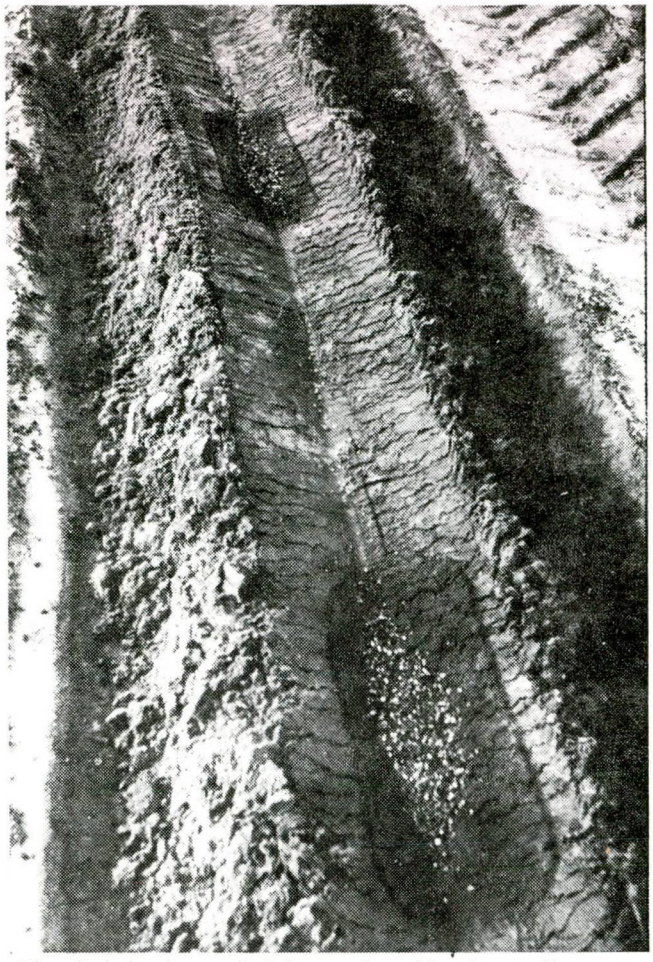
Washing the seeds before sowing will improve the establishment of some ecotypes of river saltbush and is not detrimental to others.

The harvested seeds include the true seeds covered by two salt-rich bracts. To wash salt from the bracts, soak the seeds in water for several hours then rinse them. Dry the seeds thoroughly. Seeds may be washed up to a few weeks before sowing.

Niche seeding

Salt-affected land is often situated in low-lying areas where run-on water causes waterlogging and erosion problems in winter. Appropriate measures should be

continued overleaf



The slightly elevated niche produced by the Mallen niche seeder, showing a deposit of seeds and vermiculite mulch covered with a black latex spray.

taken to minimise these problems before sowing salt-affected areas. Advice on soil conservation is available from offices of the Department of Agriculture.

The niche seeding technique has been designed for establishing salt tolerant forage shrubs on salty soils. The machine forms a low ridge on the soil, presses a niche and deposits seeds, mulch and black spray at intervals in the niche. Seeders are available commercially and areas can be seeded by contract.

On bare areas where weed competition is not expected to be a problem, the soil should be scarified or chisel ploughed before the opening rain to assist salt leaching. The area should be sown after the opening rain.

If the season is very late, bluebush can be sown dry on bare areas if the soil is soft enough to allow a niche to be formed.

On areas with barley grass or annual ryegrass wait for a germination and spray for weed control before sowing. Measures to improve weed kill, such as burning dry grass and roughening the ground to stimulate weed germination, should be used where possible.

When seeding with the niche seeder the Department recommends using the No. 4 grade of vermiculite (available from W.A. Mineral By-Products). Dilute the bitumen emulsion 1:3 with water before applying. The biggest improvement (up to a tenfold increase) in establishment is by using vermiculite, but a further improvement results from also using bitumen emulsion. Further research is required to quantify the benefit from bitumen emulsion.

Insects, including red-legged earth mites, various grubs and Rutherglen bugs have all been observed to cause seedling losses. A careful watch should be kept for these pests. Spray if necessary.

If the recommendations for pre-cultivation weed control, seed treatment, planting and insect and grazing control are followed at least 60 per cent of placements by the niche seeder should give established bushes.

Grazing

Stock should preferably be excluded from paddocks for 22 months after seeding. Where first year growth is especially good, a moderate grazing can be taken off after 10 months. After the second year the shrubs can be grazed heavily during late autumn-early winter and protected at other times of the year. Under this grazing system the shrubs should support sheep at a rate of at least 15 sheep per hectare for two months each year.

Suppliers

Enquiries concerning seeds, machines and contract seeding should be directed to:
W.C. Diamond & Co., "Guyscliffe", Maya 6614.
Kimberley Seeds Pty Ltd, 51 King Edward Road, Osborne Park 6017.
Nindethana Seed Service, Narrikup 6326.
E.N. North, Pintharuka 6623.

Further information

The following Farmnotes cover other aspects of saltland treatment:

- Farmnote No. 23/80—'Salt-water couch for salty seepages in lawns' (Agdex 343/20).
- Farmnote No. 4/82—'Samphire for waterlogged saltland' (Agdex 332/512).
- Farmnote No. 34/82—'Puccinellia—its grazing value and management' (Agdex 333/10).
- Farmnote No. 44/83—'Collecting and treating bluebush seed' (Agdex 332/20)
- Farmnote No. 83/85—'Spray.Seed® for Puccinellia establishment' (Agdex 333/21).

Note:

Bluebush seed can be obtained from I. Pulbrook—telephone (099) 72 3020 or D. Eylwood—telephone (099) 61 5215.

The use of **black sprays** (bitumen emulsion or paint) with the niche seeder is expensive—they can be omitted to reduce costs.

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Farmnote
No. 61/88
replaces 34/82

Western Australian Department of Agriculture

Agdex 333/10
Saltland plants/management

Puccinellia - its grazing value and management

By Tim Negus, Officer in Charge, Narrogin

Farmer experience and research in recent years have provided a number of pointers for those farmers wanting to use puccinellia pastures on salt-affected land.

Puccinellia (*P. ciliata*) is best suited to thick and patchy barley grass areas. In some areas it may be more difficult to establish on highly saline, bare land. It can tolerate cold weather, waterlogging and even flooding.

Maintaining a cover of puccinellia will help prevent the severe loss of top-soil from the salty land and also reduce evaporation from the soil which brings more salt to the surface. This Farmnote describes the circumstances under which puccinellia is suitable, and the necessary establishment and management.

Description

Puccinellia is a perennial grass that forms tussocks. Its leaves are long and thin and the growing points are well embedded in the base of the plant, which is compact and resistant to grazing.

It has small seeds borne in a relatively rigid open panicle. Shoots can grow up to 70 cm high in a well fertilized stand but may be only 10 cm high on poor plants.

The plants brown off in December and remain dormant over summer. They shoot vigorously after the opening rains of autumn. Heading starts from about September onwards and the seed is generally ripe by December. Seed is not shed readily and harvesting may be delayed until late summer with loss of seed.

Analysis has shown that there is little difference in the nutritional value of dry puccinellia, mediterranean barley grass (*Hordeum geniculatum* All.)† or annual ryegrass. The crude protein contents of 4 per cent and digestibilities of about 50 per cent are common. The palatability of puccinellia appears to be very good, possibly due to the retention of some sappy green stems late into summer. Barley grass is notoriously unpalatable due mainly to its spiky seed heads. It also creates a seed problem in fleeces.

Conditions for growth

Puccinellia is most suitable for the agricultural areas with 375 mm or more annual rainfall. Good stands have been grown with lower rainfall but establishment is more risky.

Puccinellia is suitable for saltland that is either bare or covered with mediterranean barley grass. It will tolerate winter waterlogging to some degree and can often be found in channels that flow for short periods in winter. However, it does not tolerate waterlogged conditions in summer and on these seepage areas sea-shore *Paspalum vaginatum*, is more suitable. Around seepages there are often bare fringes that are dry in summer or else areas of mediterranean barley grass. These areas are more appropriate for puccinellia.

Puccinellia is particularly suitable where salinity is caused by valley waterlogging. Often large expanses have become bare or covered with mediterranean barley grass and it is possible to establish sizeable stands of puccinellia.

Morrel soils are naturally highly saline, but not affected by seepage or a water table. These soils are found in the lower rainfall areas and are more suited to bluebush, *Maireana brevifolia*, and saltbushes (*Atriplex* sp.) than puccinellia.

Establishment

Grazing control is essential for establishing any salt tolerant plant. Sheep tend to congregate on saltland and eat out all palatable plants. Newly established puccinellia plants are particularly susceptible when small. If the area of salt is too small to be fenced off, another, although less preferable time to establish puccinellia, would be when the paddock is put into crop and grazing protection can be provided from sowing until late summer.

Puccinellia seed is commercially available and should be sown soon after the break of the season. The seed is small and should be broadcast on the surface of the soil at about 2 kg/ha. Higher seeding rates of up to 4 kg/ha may give a thicker initial stand. The seed can be mixed with superphosphate to aid distribution without adverse effects, given no more than one or two days delay before sowing. Alternatively, the seed can be mixed with dry sand as the carrier.

One cultivation is necessary to break up any surface seal or compaction, provide a seedbed, and allow penetration of rain to leach out salt accumulated during summer. On bare ground free of barley grass, the seed can be sown in autumn before the opening rains, but if salinity is high, later sowing will allow some leaching.

The greatest problem in puccinellia establishment is control of mediterranean barley grass. This has a larger seed, germinates quicker and its competition hinders puccinellia establishment. Methods of control vary with conditions, weather and the ability to get onto the ground. Control has been achieved by using one cultivation to stimulate barley grass germination with one or two subsequent cultivations to achieve seed kill. However, this has not always been possible as bogging is a problem in some areas.

The best stands are established using a spray seed technique to control the barley grass. The technique involves a hot burn of barley grass in autumn, followed by spraying of germinated barley grass four to six weeks after the opening rains.

Under normal conditions 2 L of Spray.Seed® in 100 L of water per hectare is used.

If the barley grass has been grazed hard and short, 1.5 L of Spray.Seed® in 100 L of water is sufficient.

Cultivation and seeding of puccinellia should be done in one operation a day or two later. A combine can be used with the seeding tubes pulled out to allow the seed to drop onto the soil surface. Harrowing is undesirable as it may bury the seed too deeply. Light harrowing is likely to be worthwhile on a very flat, fine seedbed only.

Continued overleaf...

Apply 2 kg/ha of good puccinellia seed, which can be mixed in 100 kg/ha superphosphate. Higher seeding rates of up to 4 kg/ha can be worthwhile if a cheap source of seed is available, for instance when harvesting seed on the farm.

Growth will be improved by a dressing of about 70 kg/ha of ammonium nitrate or equivalent nitrogenous fertilizer (50 kg urea/ha) applied at sowing. Superphosphate may benefit establishment of puccinellia in its first year, but unlike nitrogen, is unlikely to give any response afterwards. From 50 to 100 kg of superphosphate/ha at sowing would be suitable.

Protect the young pasture from grazing for at least 18 months (two winters).

Fertilizers

Puccinellia responds especially well to nitrogenous fertilizer, but it is unlikely to respond to superphosphate once established - even with a history of low superphosphate application.

Applications of 100 kg/ha of Agran 34:0 have given production increases of about 800 kg/ha of dry matter in higher rainfall areas and 500 kg/ha in low rainfall areas. Nitrogen application is particularly worthwhile if it is intended to harvest seed during the following summer.

Superphosphate can be beneficial in the first year of sowing, especially if the area has had little superphosphate in the past. It is unlikely to give any response in later years unless on new land in high rainfall areas with no previous superphosphate history and where nitrogen is being applied. In this case an application of superphosphate at 100 kg/ha can be given, but it will not always be profitable, and probably never be profitable if there have been one or two applications of superphosphate in the past.

Grazing management

After opening rains, puccinellia produces green feed quite rapidly and grazing can be continued at lower stocking rates into the winter months. Stock should be removed by the end of August to allow for seed development and to thicken up stands to provide ground cover during spring when salt accumulation on the soil surface is at a maximum on bare ground.

Mature stands are best grazed off as dry feed in the February to May period, when extra grazing is always useful.

Harvesting seed

The seed of puccinellia is very small and light, which makes it difficult to harvest. However, seed yields of 100 kg seed/ha or more are common from good stands. Nitrogen should be applied to seed production plots as it will increase seed yields considerably, by perhaps one kilogram of seed per kilogram of nitrogen added.

Seed ripens by December and can be harvested any time in summer as there is little danger of it shedding. January or February are most suitable when cereal harvesting has finished. Warm dry conditions are the best.

Various methods of harvesting have been used successfully. Initial costs can be reduced by establishing a seed plot and harvesting seed to spread over wider areas.

Forage harvesters or toppers can be adapted to give a rough sample. Remove the windrowing auger or attach a collecting tray to the windrowing outlet.

A conventional cereal harvester can be used. The closed front or comb type machine is best. Use the maximum drum speed with a drum clearance 1.5 mm front and rear. Cut the air blast by loosening belts and covering vents. Use a wheat riddle on top, a lupin plate fitted to the rear and a rape screen on the bottom. The puccinellia seed is taken off into the seconds box.

Production from old puccinellia pastures can drop to a very low level after 10 to 15 years. Regeneration techniques are not fully known, but cultivation in early winter creates a rough seedbed to trap seed that falls during the summer period and this may be beneficial.

Harvesting good high stands of puccinellia with a header or pasture topper is a cheap way of getting enough seed for regeneration purposes and to establish new pastures on a progressive basis.

Summary

Sow puccinellia in autumn or early winter at 2 to 4 kg seed/ha, broadcast on a cultivated surface. Prepare the site by burning and spraying to obtain complete barley grass control.

Remember - for successful establishment and management of any puccinellia pasture on saltland, fence off the area from adjoining non-salt land.

Further reading

- Farmnote No. 133/84 'Saltland management - the catchment approach' (Agdex 330/20).
- Farmnote No. 32/86 'Saltland management - selecting forage plants for saltland' (Agdex 512).

† The plant known in the past as sea barley grass (*Hordeum marinum*) in Western Australia has been found to in fact be mediterranean barley grass (*H. geniculatum* All.).

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Western Australian Department of Agriculture

Agdex 333/21

Spray.Seed® for Puccinellia establishment

By T.R. Negus, Officer in Charge, Narrogin District Office

Salt affected land carrying thick or patchy barley grass can be converted to nutritious, palatable Puccinellia grassed pastures.

Trials by the Department of Agriculture in the Narrogin district have shown that it is essential to control barley grass during Puccinellia establishment. Seed should be broadcast onto the surface of rough cultivated soil and stock excluded for at least two winters. The recommended seeding rate of 2 kg/ha might be raised to 4 or 6 kg/ha if the seed quality seems poor or if a heavy seed nursery stand is needed, or if the cost of seed is of no concern.

For successful establishment, the following four-step system should be followed carefully:

Step 1—burn off dry barley grass

A hot burn in March kills much of the barley grass seed lying on the ground surface or still in the seed heads. It also cleans the ground surface and allows more effective spraying of young barley grass seedlings after the opening rains.

Unburnt dense stands of dry barley grass shelter the germinating seedlings from the direct action of the herbicide and poor weed control results.

Step 2—apply Spray.Seed®

Germination of barley grass is slow on salt-affected land, therefore spraying should be delayed for four to six weeks after the opening rains. By then, most of the barley grass seed which survives the hot burn should have germinated.

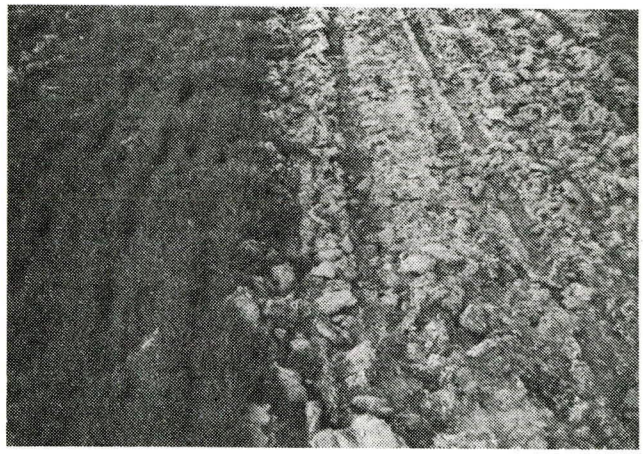
If ungrazed, the young barley grass should be sprayed with up to 2.0 L of Spray.Seed® in 50 L of water per hectare. If the barley grass has been grazed hard, up to 1.5 L of Spray.Seed® in 50 L of water per hectare should be adequate.

If it has not been possible to achieve a good hot burn, high rates of chemical and water are required and it would be advisable to postpone the project until the following year.

Step 3—cultivate and seed

Cultivate the area for the first time with a combine, one or two days after spraying. In the same operation, with the fertiliser tubes pulled out of the boots, Puccinellia seed mixed with about 100 kg/ha of superphosphate is dropped onto the soil surface.

If heavy clay is involved, a scarifier may be needed to break up the soil immediately in front of the combine. Once the area has been cultivated, it is essential to seed the Puccinellia before further rain makes the area impassable. Direct drilling with a combine onto the sprayed undisturbed surface avoids most bogging problems, even as late as mid-June. Covering harrows are not necessary.



Good control of barley grass is required before seeding Puccinellia. On the left, conventional cultivation failed to achieve good weed control compared to the spray-seed technique on the right.

Young Puccinellia pastures should be fenced during the first year as seedlings are pulled out by grazing stock.

Step 4—fence off the Puccinellia pasture

Stock must be kept off the pasture for the first 20 months to enable the young Puccinellia plants to develop a good root system and crown. If grazing occurs during the first summer many Puccinellia plants are pulled out of the ground by sheep and the pasture is severely thinned.

Establishment of saltland pastures has always shown variable results. By following the above four-step system closely, the chances of success are greatly increased on mild to moderately saline land with patchy to thick barley grass cover. Establishment on very saline, bare soil is always more difficult. Scarifying, spreading a straw mulch then broadcasting seed on the mulch has been successful in some cases.

Further Information

•Farmnote No. 61/88, 'Puccinellia-its grazing value and management" (Agdex 333/10)

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Farmnote
56/88
...aces 4/82

Western Australian Department of Agriculture

Agdex 332/512
Shrubs/saltland management

Samphire for waterlogged saltland

By Clive Malcolm, Principal Research Officer and Graham Cooper, Technical Officer, Northam

For non-waterlogged and mildly waterlogged saltland, a number of salt-tolerant shrubs may be used for forage production. These shrubs are not suited to areas which are highly saline and regularly waterlogged. However, in Department of Agriculture trials with different shrub species, samphires (*Halosarcia* spp.) volunteered and grew well on these sites.

Background

Samphires are a group of succulent, highly salt-tolerant, perennial shrubs. They are found on waterlogged saltland throughout the agricultural areas in Western Australia. Established samphire stands provide useful grazing in many parts of the Western Australian wheatbelt.

Extensive, natural stands of samphires are associated with the salt lake systems in the wheatbelt. However, samphires have also volunteered on land which became salty after development.

The most common species are black-seeded samphire (*Halosarcia pergranulata*), pale-seeded samphire (*H. lepidosperma*) and woody-seeded samphire (*H. indica* spp. *bidens*).

The woody-seeded samphire is most common in the northern wheatbelt. The other two species are widely distributed, with black-seeded samphire more common than pale-seeded samphire. There are a number of other species of lesser importance.

Research into the use of samphires has shown that it is possible to harvest seed and obtain a seed sample suitable for sowing through a drill.

Seed harvesting

Samphire plants do not have true leaves. The stem is thickened into a succulent cylinder with joints at the points where leaves or shoots would normally be. The seeds are produced on elongations of the stem on black and pale-seeded samphire, but in woody-seeded samphire the seeds are on small shoots attached to the main stem.

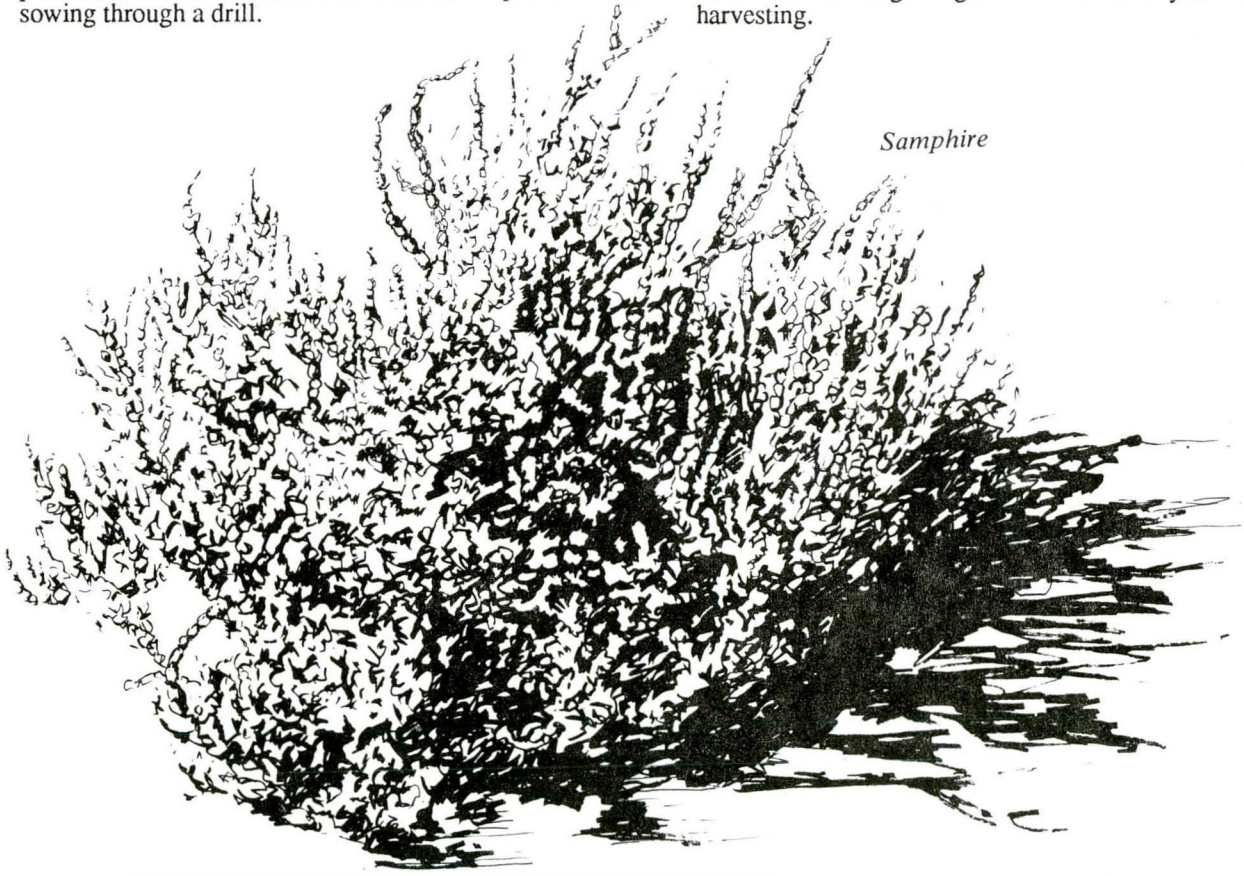
Mechanical harvesting of woody-seeded samphire has not been tried, but is possible with the other samphires.

A forage harvester is used to cut the bushes. The cut material may be spread directly on to areas to be seeded or it may be spread in a layer several centimetres thick on a bare salty area to dry. When dried, a side delivery rake is used to separate the stems and knock the seed-heads off. As a result, a layer of seed-heads and broken plant material three to five centimetres thick remains on the soil. This material can be spread on saline areas without further treatment or it may be threshed and cleaned to obtain a sample suitable for a seed drill. Threshing is preferred because germination improves and the material can be spread more evenly.

Clover seed cleaning machinery will handle dried samphire seed-heads or they can be passed through a series of different sized vibrating screens.

Harvest in late summer when the mature seeds can be seen embedded in the green fleshy seed-heads. The ripe seeds of black-seeded samphire are easily identified by squashing the seed-heads in the palm of the hand.

Harvesting destroys the existing bushes but normally a good stand of seedlings regenerates in the year following harvesting.



Samphire

Germination and establishment

Samphire seeds have a natural ability to remain alive in saline soils and to germinate when conditions become suitable. Black-seeded samphire is known to have a proportion of 'hard' seeds which may germinate in the second season after sowing.

Black-seeded samphire has been established in field trials by scarifying the ground and spreading the seed material on the soil surface in autumn before the first rains.

The plants normally remain very small (1 cm to 2 cm tall) until summer, then may grow to about 0.5 m high by autumn. Grazing protection during the first summer and autumn is essential.

Grazing and management

The common black-seeded samphire contains about 14 per cent crude protein on an oven dry basis. Pale-seeded samphire tends to be higher in salt and lower in protein.

As the plants normally contain about 20 per cent chloride avoid excessive salt intake by the grazing animals. Because sheep are more salt tolerant than cattle, samphire is better suited to grazing by sheep. Under farm conditions, samphire has supported 0.5 to 0.8 dry sheep equivalents per hectare. However, animals can usually graze samphire in autumn only.

Grazing precautions are similar to those adopted when moving sheep from a fresh to a salty drinking water supply. Avoid sudden, large intakes of samphire. Special care must be taken with ewes and young sheep. It is important to provide water with a low salt content, otherwise the overall salt intake is likely to be too high. Adequate trough space must be available to ensure all sheep have free access to fresh water.

The most practical way to ensure that sheep do not eat excessive quantities of samphire is to have other feed available or to feed hay. In some areas it is possible to sow Puccinellia in the samphire stand to provide an alternative feed. Providing these precautions are observed, samphire can be grazed usefully.

Samphire is most useful for late summer and autumn grazing because other feeds are scarce at this time of the year. Grazing at this time also allows the plant to make normal summer growth and produce seed for regeneration. However, continuous heavy grazing will kill the samphire stand.

Well managed, mature stands of samphire usually thicken-up and improve. They are occasionally invaded by some annual pasture species in favourable spots to provide a useful supplement to the samphire. Unfortunately, this does not indicate that the saline area has been reclaimed - it would still be unsuitable for cropping.

Further reading

- Farmnote No. 43/83 'Seeding shrub pastures on saltland' (Agdex 332/21).
- Farmnote No. 44/83 'Collecting and treating bluebush seed' (Agdex 322/20).
- Farmnote No. 133/84 'Saltland management - the catchment approach' (Agdex 512).
- Farmnote No. 31/85 'How to raise saltbush and bluebush seedlings' (Agdex 332/21).
- Farmnote No. 32/85 'Gypsum improves soil stability' (Agdex 514).
- Farmnote No. 83/85 'Spray. Seed® for Puccinellia establishment' (Agdex 333/21).
- Farmnote No. 44/86 'Saltland management - revegetation' (Agdex 330/10).

Forage harvesting of samphire

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No 28/87
Replaces 23/80

Western Australian Department of Agriculture

Agdex 333/20

Salt-water couch - for salty seepages and lawns

By Officers of the Division of Resource Management

Salt-water couch†, *Paspalum vaginatum*, has an amazing ability to thrive in wet salty areas. It is also a good lawn grass. Seed of the grass is not available but it may easily be established by planting pieces. Salt-water couch is sold under a variety of common names.

Recently, it has been shown that the correct scientific name for the species commonly called Salt-water couch is *Paspalum vaginatum* not *Paspalum distichum* as previously thought.

This Farmnote reviews where and how the grass may be used.

Where to use it

Bogs, gullies and seepage areas which stay wet, even with salty water, during the summer are ideal situations for growing *Paspalum vaginatum*. It will form a dense mat of roots which stops erosion and reduces bogging, and will turn the areas into green "lawns". When established, it is very resistant to grazing and provides valuable green feed during the hotter months.

Where to plant it

Since *Paspalum vaginatum* is a summer grower, it is best planted when its growth commences in the spring, around August-September, to give it a chance to become established before summer. In very wet seepages, however, plantings made in mid-summer will be successful. Under the most favourable conditions, one small piece of root may spread to cover an area one metre in diameter by the end of autumn.

How to plant it

Paspalum vaginatum can be established from roots. The amount available for planting determines how it should be used. Small amounts are best formed into a nursery plot by planting the roots in the most favourable situation. This will probably be the wettest part of the seepage area or may be an area where water can be supplied.

Later plantings may be made from the nursery plot when time permits. If roots are abundant they may be tried in a number of different areas to find out by experiment where it is of most use.

The drier the area the more care is required in planting. In very wet boggy patches runners thrown on the surface will grow, but it is advisable to tuck them into the soil. In areas which are less wet it is best to cut and plant small sods of turf about four to six centimetres square. These should be planted with the top of the sod level with the ground surface.

In gullies, creeks and bogs it is convenient to carry the ready cut or teased *Paspalum vaginatum* pieces in a bucket or wheelbarrow and use a mattock or hoe to open the soil at regular intervals for planting. Treading each piece down consolidates the job.

On larger, drier areas where it is possible to use implements, sods of the grass may be planted in a furrow made with a plough. A further adjacent run with the plough may be made to partially cover the sods, and running the tractor wheels over the planting makes it firm.

How to treat it

Until bare areas have been covered with grass, they will benefit from grazing protection, since sheep crop the grass closely and stop runners colonising surrounding bare soil.

Salty soils usually develop a hard surface crust, which should be broken to assist runners to root.

Mulching the bare areas with a covering of hay or straw is also helpful since it keeps the soil cool and soft.

Once *Paspalum vaginatum* is established over the whole of the suitable area, it is virtually impossible for it to be eaten out.

On non-salty areas, *Paspalum vaginatum* responds to phosphate and nitrogen fertilisers. As the area becomes more salty the response to fertilisers is less obvious and only in the case of *Paspalum vaginatum* growing on fairly fresh seepage areas will the application of superphosphate and urea be warranted.

As a lawn

Good lawns of *Paspalum vaginatum*, also known as Saltene®, can be grown with fresh water. Water and fertiliser requirements are similar to couch. It produces vigorous runners but it is not as aggressive in the garden as couch or kikuyu. Growth in shaded areas is similar to couch and buffalo in winter but survival is better and the warm weather restores a continuous turf. It is a soft, medium textured grass which tolerates a moderate amount of wear during the warm months when actively growing.

Many people have the problem of growing a lawn with salty water or soils. Fortunately, couch and buffalo grasses are reasonably salt tolerant and some lawns of these grasses are successfully grown with water containing up to 730 millisiemens per metre electrical conductivity (4,000 milligrams per litre of total soluble salts).

Paspalum vaginatum provides an opportunity to have a good lawn with even saltier water. Little precise information is available, but it is possible that good lawns may be grown with water containing up to 2,550 millisiemens per metre electrical conductivity (14,000 milligrams per litre of total soluble salts), where ample water is applied and leaching can be ensured to avoid excess salt accumulation. When relatively salt-sensitive plants are growing nearby, careful application of water is necessary to avoid salt injury to them.

Where to get it

Many farmers have considerable areas of *Paspalum vaginatum* established and are willing to allow others to dig runners from their properties. Where no such areas are known, agricultural advisers at Department of Agriculture district offices can usually suggest sources of supply. If this fails, the Division of Resource Management of the Department of Agriculture, Baron-Hay Court, South Perth, should be contacted. Some plant nurseries in the Perth metropolitan area also sell this grass.

† The Australian Nomenclature Committee has chosen the common name 'salt-water couch' instead of 'seashore paspalum' which was previously used in Western Australia.

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Farmnote
No 5/86

Western Australian Department of Agriculture

Agdex 550

Drainage of saline and waterlogged soils

By Les Lenane, Technical Officer, Moora and Ross George, Research Officer, Division of Resource Management

Soil salinity and waterlogging are usually caused by a complex combination of processes and seldom by a simple single process, but management of water is the key to reclamation.

This Farmnote discusses 'whole catchment' management of water with emphasis on surface and subsurface water in the valleys.

Water management

Water on the farm can be managed on slopes and on flat land and valleys (see Farmnote No. 133/84).

Slopes

On slopes, aim to prevent water and salt moving onto saline areas and ensure an even spread of water over the soil. This maximises water use by plants and prevents erosion.

This is achieved by:

- Appropriate siting of fences, gates, farm tracks, watering points and races through farm planning.
- Planting 'high water use' crops like lupins or barley and planting trees on likely recharge areas such as unproductive,deep sands.
- Using stubble mulching or minimum tillage with good agronomic practices to reduce run-off and improve crop growth.
- Minimising the period of fallow.
- Earthworks, such as grade banks, interceptor drains, or absorption banks where there are no waterways.

Flat land and valleys

On flat land and valleys, aim to improve growing conditions for salt tolerant and non-salt tolerant plants by reducing waterlogging and encouraging salt to leach from the soil.

This is achieved by:

- Re-vegetation with trees for shade and shelter belts, salt tolerant forage shrubs and grasses.
- Shallow surface drains and levee banks for flood control.
- Using open drains or tube drains (corrugated plastic tubing) for subsurface drainage.

Drainage of flat land and valleys

Drainage is not the only treatment for waterlogged and saline flat land, but is an important part of water management on farms.

Drainage can be by shallow surface drains, levee banks and subsurface drains.

Shallow surface drains

Shallow surface drains remove water from an area quickly, with minimum soil erosion and silting, and are a discharge point for contour banks and paddock run-off (see Farmnote No. 120/84).

Levee banks

Levee banks confine water to a planned channel. Levee banks have a limited ability to contain peak flows and they should allow for water inflow from adjoining paddocks.

Subsurface drains

There are two types of subsurface drains: interceptor drains and relief drains.

- Interceptor drains: intercept run-off and shallow, subsurface seepage flow to control waterlogging of non-saline duplex (sand over clay) soils (see Farmnotes No. 19/83 and 20/83). Also, they control waterlogging around salt areas (see Farmnote No. 66/85). They will not control watertables beneath salt areas where water is rising under pressure from a deep aquifer.
- Relief drains: control the depth of watertable by removing groundwater. Good drainage will control waterlogging and assist leaching of salts. Even when surface water is controlled, subsurface drainage may still be necessary to reclaim the site for crop production.

Investigating sites for subsurface drainage

The most important part of a drainage programme is the investigation which determines what type of drainage work, if any, is needed.

The following notes will assist an investigation. Each site is different and should be assessed on its merits.

Disposal

From aerial photographs and maps, determine the drain outlet. Obtain agreement with downstream neighbours; consider the level of crossings under main roads, shire roads and railway reserves and any adverse effect of drainage water on downstream land and water. Consider the effect of saline effluent on existing vegetation; especially in flora and fauna reserves and National Parks. Increased inundation with even relatively fresh drainage water can destroy natural vegetation.

From the topographic survey and planned depth of drain, determine whether the grade is adequate for gravity discharge. Consider soil types and geology to assess whether unstable soils or shallow rock will restrict the depth of drain and disposal of water. For example, sands are unsuitable soils for the construction of open drains.

Topography

Examine landscape and aerial photographs to plan the course of the proposed drains.

When siting drains, consider:

- Other conservation structures and overall farm planning.
- Cost of construction.
- Treating the greatest area for the least cost.
- Feasibility of construction.
- Surface topography. A contour survey is necessary for a parallel system of tube drains. Minimum grades of 0.01 to 0.005 per cent are desirable for open drains and 0.15 to 0.2 per cent for tube drains.

Continued overleaf

Soil

Dig backhoe 'observation' pits along the course of the proposed drain, about 250 metres apart, but at more frequent intervals if there are obvious changes in the landscape. Dig a few transects across the drain if necessary. Generally, open drains should be constructed in the lowest part of the landscape.

Preferably, observation pits should be aligned across the drainage course.

During construction of observation pits look for:

- Evidence of a water transmitting layer(s).
- Texture of soil layer(s)—the clay content is particularly important.
- Speed of water flow into the pit. Very slow seepage flow indicates poor prospects for drainage.
- Depth of water transmitting soil layer(s) and whether there is continuity with other pits.
- Presence of 'hard pan' or clay layers which may obstruct downward leaching.
- Indications that the soil may erode or slump if an open drain is constructed.
- The source of water. It may be lateral flow or upward seepage bringing salt and water to the surface.
- Signs of iron contamination in the groundwater; for example, the presence of an 'oily' film on stagnant water.
- Features of the soil geology in pits that are dug across the drain. For example, permeable layers may 'peter out' or there may be changes in the depth to hard pans or bedrock.
- The correct position for the drain across the valley or flat.
- Whether more than one drain is needed.

Planning decisions

Much experience is needed to design drainage systems. If drainage is feasible, then it is necessary to consider:

- Drain type: there are shallow surface drains, deep open drains and slotted tube drains. Open drains control both surface and sub-surface water and can usually be installed at a greater depth than tube drains.
- Filters: may be needed when using slotted tube drains. A gravel filter around the pipe is required if the water bearing material is fine sand or silt which flows when wet. Because of 'sealing' problems, woven nylon filters should not be used where groundwater contains high levels of iron.
- Crossings: the size and position of crossings must be decided if open drains are planned.
- Drain spacing: calculated from soil hydraulic conductivity (permeability), drain depth and the amount of excess water affecting the site. Where a parallel system of drains is needed, spacing greatly affects cost. Generally, the faster water flows through soil, the wider the drain spacings. If the depth of drains is increased, they can be spaced further apart.
- Drain depth: drains should intersect the best water transmitting material. Since the watertable should be deeper than 1.5 metres to control salinity, the drain depth must be 1.8 to 2 metres. Shallower drains will reduce waterlogging and help alleviate salinity effects on plants.
- Soil improvement: gypsum or deep ripping may be needed to improve water infiltration and leaching of salts. Select areas that are not severely degraded by salinity and/or loss of topsoil.

Costs

Drainage can be very expensive and needs to be carefully 'costed out'. Consider alternatives to drainage and discuss the whole programme with those experienced in drainage work.

Open drains built with an excavator cost between $1,300 and $1,800 per kilometre in January, 1986. The cost is higher if a lower batter slope is used to reduce maintenance.

The cost of tube drains was $1.30 per metre for 65 millimetre diameter pipe and $2.20 per metre for 100 millimetre diameter pipe in January, 1986. The cost of installing tube drains by the 'trenchless' method is between 25 and 50 cents per metre.

Maintenance

Open drains are susceptible to silting because soils in salt areas are unstable. Construct open drains with a continuous levee along each side and provide pipe inlets to allow inflow of excess surface water. Silt should be removed every 2 or 3 years: if silt is allowed to build-up the drain may become ineffective. At present, this costs $250 to $500 per kilometre depending on the depth of silt to be removed.

Many groundwaters in the wheatbelt contain significant levels of iron. This can precipitate as an iron oxide gel and block tube drains. Periodic flushing of tube drains will prevent excessive iron build-up. If iron materials do build-up and harden then corrosive and toxic sulphur dioxide gas is needed to dissolve them.

Further reading

- Farmnote No. 19/83—'Reverse-bank seepage interceptor drains' (Agdex 572).
- Farmnote No. 20/83—'Surveying and construction of reverse-bank seepage interceptor drains' (Agdex 572).
- Farmnote No. 120/84—'Spoon and W-drains' (Agdex 554).
- Farmnote No. 133/84—'Saltland management—the catchment approach' (Agdex 512).
- Farmnote No. 66/85—'Controlling surface water flow above salt-affected areas' (Agdex 572).

ISSN 0726-934X

Farmnote
5/91

Western Australian Department of Agriculture

Agdex 558
Legal aspects of drainage

Notification of draining or pumping saline land

Regulation 5 of the Soil and Land Conservation Amendment Regulations (No. 3) 1990 requires owners or occupiers of land to notify the Commissioner of Soil Conservation at least 90 days before a new drainage or pumping scheme (set up because of the salinity of the water) discharges water on to other land or into water or a watercourse.

A copy of the form for notifying the Commissioner (Schedule 4) is printed overleaf.

Drainage is being increasingly used to treat land salinization. Saline water tables can be lowered by deep tube or open drainage, and by aquifer pumping. Lowering the water table below a critical level will stop salt accumulation near the soil surface.

However, drainage of land can have significant deleterious off-site effects.

Pumping or draining saline water then discharging it on to other areas or into a waterway may degrade surrounding land or public land and utilities. Land or waterways further away may also be significantly salinized by the discharge water or made unnaturally wet.

The saline water can be considered a noxious effluent causing a nuisance downstream. Other damage from the saline water can be a loss of private or public amenities, such as the degradation of natural vegetation or damage to roads or culverts, or an increase in soil erosion.

When considering draining, a land user must be aware of obligations and responsibilities to neighbours and the general community. There are several Acts and legal requirements that must be considered before undertaking drainage or aquifer pumping.

New regulations

New Regulations under the Soil and Land Conservation Act require landholders to notify the Commissioner of Soil Conservation of new schemes:

- to pump saline groundwater; or
- to drain saline water.

For the purposes of notification, saline water is defined as:

- water with more than 2,000 mg/L Total Soluble Salts (conductivity of about 360 mS/m); or
- water more saline than the water into which it is being discharged.

The Commissioner should be notified at least 90 days before the pumping or drainage starts by means of the form (Schedule 4) printed overleaf. The form has spaces for details of starting date, period of pumping or draining, who is doing it, where, and where the water is to be discharged.

Failure to notify the Commissioner is an offence carrying a $1,000 penalty.

The Regulations are not meant to apply to the seasonal start-up of existing schemes, only to new ones. The Regulations apply even if discharge is on the same property.

Public notification

If the Commissioner considers that the discharge of saline water may cause salinity problems off the property, he notifies relevant public authorities (such as the Department of Conservation and Land Management, Water Authority of Western Australia, Environmental Protection Authority, Shire Councils) and relevant land conservation district committees.

Other relevant legislation

Landholders should be aware that six Acts could be relevant to land drainage and acquifer pumping.

- *Soil and Land Conservation Act*: Controls practices that cause land degradation.
- *Land Drainage Act*: Applies to declared drainage districts.
- *Rights in Water and Irrigation Act*: Regulates the discharge of pollutants into streams.
- *Country Areas Water Supply Act*: Applies to surface catchments and groundwater systems used for public water supplies, where effluent disposal is controlled by the Water Authority.
- *Effluent Control Act*: Prohibits the entry of noxious effluents into streams, water bodies, gazetted drains or any aquifer leading into these.
- *Environmental Protection Act*: Controls effluent disposal that may have a detrimental environmental impact. Administered by the Environmental Protection Authority.

Further reading

- Farmnote No. 79/86 'Legal aspects of land drainage' (Agdex 558).

695/3/91—7,500

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DEPARTMENT OF AGRICULTURE
WESTERN AUSTRALIA

Schedule 4

(Regulation 5)

To: The Commissioner of Soil Conservation
Department of Agriculture
3 Baron-Hay Court
SOUTH PERTH W A 6151

Notice of intention to drain or pump saline water from land

I, _____
(full name, block letters)

of _____
(postal address)

propose to drain/pump saline water from about _____ hectares of land in the

municipality of _____ being

_____
(the land's title description)

_____

and being _____ km _____ (N,S,E or W) of _____
(siding or townsite)

and to discharge the water _____

_____
(describe land, water, watercourse or lake onto or into which the water is to be discharged)

_____ as indicated on the plan below. The drainage/pumping will

commence on or about _____ and will continue for _____.
(period)

I am the owner/occupier/owner and occupier† of this land. († Delete as appropriate.)

Signed _____ Date _____

Plan to be attached

(Show the direction of north, the land to be drained, the title description of the land and adjoining locations, any adjacent public roads and where the water is to be discharged.)

Farmnote
No 79/86

Western Australian Department of Agriculture

Agdex 558

Legal aspects of land drainage

By Ken Cole, Senior Adviser, Irrigation and Water Resources Branch

The law relating to land drainage is a complex combination of common law and statute law.

Any general statement of such law must be treated with caution and considered only as a guide. The facts of a particular situation must always be carefully examined, and legal advice obtained whenever the position is unclear.

Common law

Common law is based on English law which dates back to pre-Norman times and is unwritten or non-statute law. Common law is law used to obtain damages and perhaps injunctions against some act considered injurious.

Any summary of common law pertaining to certain conditions can only be a guide as circumstances alter cases. Legal advice should be sought in all situations where common law applies.

Common law applies to land waste and nuisance. Those actions which are deemed normal practice are not considered a nuisance. In Australia, land clearing and cultivation is considered normal practice and runoff and flooding due to such causes would not be considered a nuisance. Drainage, in most areas, is not a normal practice and flooding due to such causes would probably be considered a nuisance.

It is a maxim of 'common law' that 'water flows naturally and should be permitted thus to flow'.

It is important to distinguish the law of watercourses from the law of land drainage.

Water having a defined course (watercourses)

In law, a watercourse is defined generally as a stream of water which flows along a defined channel, with bed and banks, for a sufficient time to give it a substantial existence. This can include streams which dry up periodically.

The law governing watercourses is mainly in the Rights in Water and Irrigation Act and certain other statutes. It differs from the law of drainage, which is concerned with surface water not running within a watercourse.

A riparian rights owner is entitled to have the water of a stream passing through his land flow to him in its natural state, so far as it is a benefit to him, and he is bound to submit to receive it even though it is a nuisance to him by its tendency to flood his land. Therefore, unless, the flow of the stream is increased or diverted to his disadvantage in some unauthorised way by the proprietors above or below him he must submit to what is the result of natural causes.

Water having no defined course

The principles of law which regulate the rights of owners of land in respect of water flowing in known and defined channels, whether upon or below the surface of the ground, do not apply to water which runs in no defined channel, or merely percolates through the strata and no action will result from the removal or diversion of such water.

No right of drainage exists for surface water flow that is not in a defined channel. An owner of lower land may, at his own choice, either allow water from higher land to flow over it or keep such water off his property by dams or banks.

Summary of natural drainage rules

- A natural watercourse must not be obstructed or diverted.
- Surface water must not be collected and diverted to land that would not naturally receive it.
- The point of entry of surface water on lower land must not be changed.
- Water must not be brought in from another watershed.
- A landowner cannot accelerate the flow of water to the material damage of lower land.

Therefore, subject to the statutes mentioned later, any landowners whose land abuts upon a watercourse has the right to drain those lands into the watercourse, but may not bring water in from another watershed.

Legal rules as to drainage

For the purpose of explaining these rules it will be useful to consider the case of landowner A, who occupies the higher property, and landowner B, who occupies the adjoining lower property.

Landowner A

1. He is not liable for any surface water which flows naturally from his land to the land of B.
2. He may be liable if, by artificial means, he causes such water to flow in a more concentrated form than it normally would and damage is thereby caused to the land of B.
3. For him to be so liable, the concentrated flow must arise from some action beyond the 'natural' use of the land. What is 'natural' will depend on the circumstances. Thus agricultural land cleared or drained in the ordinary course of agriculture would generally be regarded as within natural use.

Landowner B

1. He can recover damages from, or obtain an injunction against, landowner A if the latter is liable to an action because he has concentrated or altered the natural flow.
2. Even where the situation is that he has no legal redress because the altered flow results from 'natural' use by landowner A, nevertheless, landowner B can resort to self-help remedies. He may put up barriers and pen back the water, even if doing so damages the land of A, provided B uses reasonable care and skill and does no more than is necessary to protect his land. What is 'reasonable' will depend on the circumstanes of each case.
3. In acting defensively (as outlined in 2) landowner B is not entitled to divert the water onto the land of a third proprietor to which it would not otherwise have gone naturally.

continued overleaf

Statute law

Any landowner undertaking drainage of his land must also take account of the legislation on the subject. The main statutes of relevance are:

- Soil Conservation Act
- Land Drainage Act
- Rights in Water and Irrigation Act. This Act makes complex provisions in respect of the water in watercourses, lakes, lagoons, swamps, marshes and springs and also in respect of underground water. They regulate irrigation schemes. They prohibit the discharge without licence of any pollution into any watercourse—this could include the drainage of saline water. They regulate the construction of certain kinds of dams.
- Country Areas Water Supply Act

Soil Conservation Act

This Act is administered by the Commissioner for Soil Conservation and deals with all facets of soil degradation.

Flooding and waterlogging are aspects of soil degradation and the Commissioner has wide powers to handle such matters.

The Commissioner cannot award damages, but may oblige a landowner to carry out certain works or desist from practices causing soil degradation.

Landowners are advised to study the Soil Conservation Act or consult officers from the Department of Agriculture before embarking on drainage activities which may affect neighbours or may lead to soil degradation.

Land Drainage Act

This Act applies to some 14 areas on the coastal plain of south-west Western Australia, from Wungong and Mundijong in the north to Torbay, west of Albany.

This Act is designed to reduce flooding and aid in the safe disposal of surplus farm water.

Land in the drainage districts is rated according to the benefits derived.

'Full benefits' entitle the land owner to dispose of his surplus water into a Government drain without fear of legal repercussions while 'general benefits' supply cut-off facilities preventing water coming onto the area from non-rated areas. General benefit areas have no direct access to Government drains.

The Perth Metropolitan area is not gazetted under the Land Drainage Act and operates under a different set of regulations (Sewerage and Drainage Act).

Country Areas Water Supply Act

This Act aims to ensure catchment streams and underground aquifers are not polluted and rendered unfit for human consumption by saline water, silt, vegetable matter or other effluents. The gazetted areas are mostly adjacent to towns and are sign posted and often fenced. Permission to use these areas for water disposal is very closely controlled and permission must be obtained from the Water Authority of Western Australia in all cases.

In addition the following Acts have some bearing on land drainage:

Effluent Control Act

This Act covers the disposal of noxious effluents. Saline water is deemed a noxious effluent, as are industrial wastes. It is not permissable to dispose of noxious effluents into drains gazetted under the Land Drainage Act or any stream, lake or ocean or where it may enter an underground aquifer causing pollution of the water body without permission from the relevant authority.

This act is likely to apply in farming areas where noxious effluents from piggeries, milking sheds, abattoirs and similar industries are concerned. The Water Authority of Western Australia must be consulted in these cases before action is undertaken by the landowner.

Environmental Protection Act

This act is mainly used to cover the disposal of surplus water into National Parks, Flora and Fauna reserves and certain lakes, streams, the ocean and land areas of ecological significance.

Where the drainage of surplus water is likely to injuriously impinge on such areas the Department of Conservation and Environment should be consulted, especially if the water is saline or semi-saline.

Note: The Main Roads Department, Westrail and Shire Councils have regulations covering the drainage of water onto their lands.

Summary

While there are a number of Acts controlling drainage and the disposal of surplus water, farmers are normally only concerned with:

- Common law, or the
- Soil Conservation Act

The other Acts are used only when, at some point, the application of these Acts arises.

Where litigation under common law my arise, legal advice should be sought before any action is initiated.

Where the Soil Conservation Act is likely to apply the Commissioner or his delegates should be consulted before work is started.

In the case of other Acts the relevant authorities will freely give advice on their respective legislation.

Seeking advice before starting a project and consulting with neighbours and authorities likely to be affected will help prevent nuisances, ill feelings and costly litigation.

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Farmnote
35 /91
replaces 87/85

Western Australian Department of Agriculture

Agdex 512
Saltland management

A simple way to monitor your saltland

By Tim Negus, Manager, Landcare Technicians Training Scheme, Narrogin

Farmers with salt affected land are often more concerned with stopping further spread of the problem than curing the existing problem. In many cases, there is little hard evidence that the area of saltland is increasing and in fact the situation may be stable. In these stable situations, the landowner may worry needlessly — the problem is unlikely to worsen.

At some sites, the area of saltland may increase rapidly, especially after high rainfall years. The farmer may get some indication of the rate of spread from changes in the cropping boundary around the saltland over the years. However, in most cases it is unclear whether the salt-affected area is increasing and, if so, at what rate.

You can set up a permanent monitoring system cheaply by carrying out the procedure described in this Farmnote.

All that is required is the loan or hire of a small 50 mm drilling rig for a day or two, a few lengths of 40 mm diameter PVC pipe and a bundle of steel posts. Analysis of some water and topsoil samples for electrical conductivity is also desirable. This may be arranged through a commercial laboratory, or through your local Department of Agriculture office.

Procedure

Select suitable sites for monitoring stations

Choose a monitoring station where the saltland boundary is suspected of spreading, and if possible where the clover/barley grass boundary is easy to identify. Two or three monitoring stations for each area of salt-affected land should be sufficient (Figure 1).

Mark the boundary

Drive in steel posts 10 to 20 metres apart exactly on the clover/barley grass boundary, so that you will easily see any change in the boundary over time.

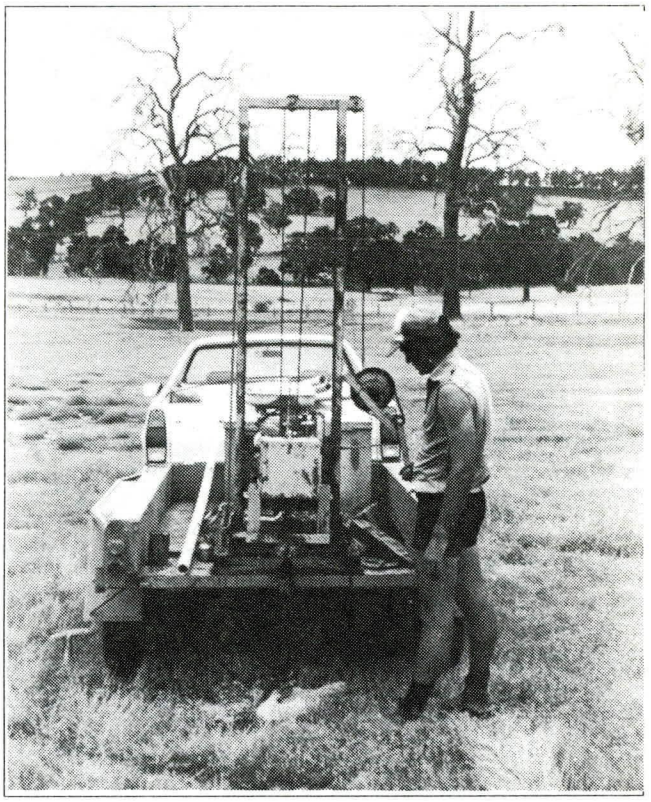
Drill holes

At each monitoring station, drill holes (about 50 mm in diameter) with a hand or power auger to a depth of 2.0 metres. Locate the holes in the bare salt, patchy barley grass, thick barley grass and non-saline (clover/grass) areas. Also drill a hole on the clover/barley grass boundary.

The distance between the holes will vary from 10 to 20 metres, depending on the width of the different salinity classes at a particular site (Figure 2).

Line the holes

Use 3-metre lengths of 40 mm PVC pipe (Class 6) to line the holes. Cut slots in the bottom one metre with a fine-bladed hacksaw. When the pipe is in the hole, pack clay or cement grout around it at ground level to prevent inflow of rainwater (Figure 3). Keep rain out of the top with an upturned jam tin or bottle. Identify the hole by a number on the top of the pipe. Prevent stock rubbing against the pipe by driving a steel post into the ground next to it or cutting the pipe off short, 20 to 30 cm above ground level.



Typical rig used for drilling holes in saltland

Soil sampling

Take soil samples from near each hole during summer. Three samples of topsoil from 0 to 5 centimetres should be bulked and mixed thoroughly. Label the sample clearly with the number of the hole in question. Get the soil samples analysed for electrical conductivity.

Table 1 provides a guide to soil salinity levels when interpreting the results from the laboratory.

Determining the critical watertable depth

The critical watertable depth is the depth at which capillary rise is able to transport significant amounts of salt into the topsoil root zone or even to the soil surface. The growth of plants at the site is first affected; for example, clover disappears.

Continued overleaf...

Table 1. Soil salinity levels and electrical conductivity analyses

Salinity level	% Chloride	Electrical conductivity† mS/m
Non-saline, clover/grass	Less than 0.03	0 to 20
Mildly saline, thick barley grass	0.03 to 0.15	20 to 100
Moderately saline, patchy barley grass	0.15 to 0.44	100 to 300
Severely saline, bare soil	0.44 to 3.00	300 to 2,000

† Electrical conductivity (in millisiemens per metre) of a 1:5, soil: water suspension ($EC_{1:5}$) at 25°C.

Look at the range of watertable depths at each station and in particular those under the thick barley grass (mildly saline), the clover/barley grass boundary, and the non-saline land nearest to the salt. This should give you some idea of the critical watertable depth for that particular site.

These measurements should be carried out in spring or early summer when the risk of capillary rise is greatest.

Take water samples

Using a weighted dipper on the end of a piece of cord (or a sludge pump — see Farmnote No.53/90 'Monitoring groundwater levels in bores'Agdex 584), take a sample of ground water. Take this to your nearest Department of Agriculture office for electrical conductivity measurement.

Long term monitoring

To detect whether the watertables are rising, falling or are stationary over a period of years, check watertable depths regularly and record or graph them in the farm office.

The most suitable time for measuring depths is in October, when the risk of capillary rise is greatest. A measurement in April should give the deepest watertable readings and one in August the shallowest depth to water.

Annual checking of the clover/barley grass boundary between the steel posts will also indicate whether the saltland problem is getting worse or is stable.

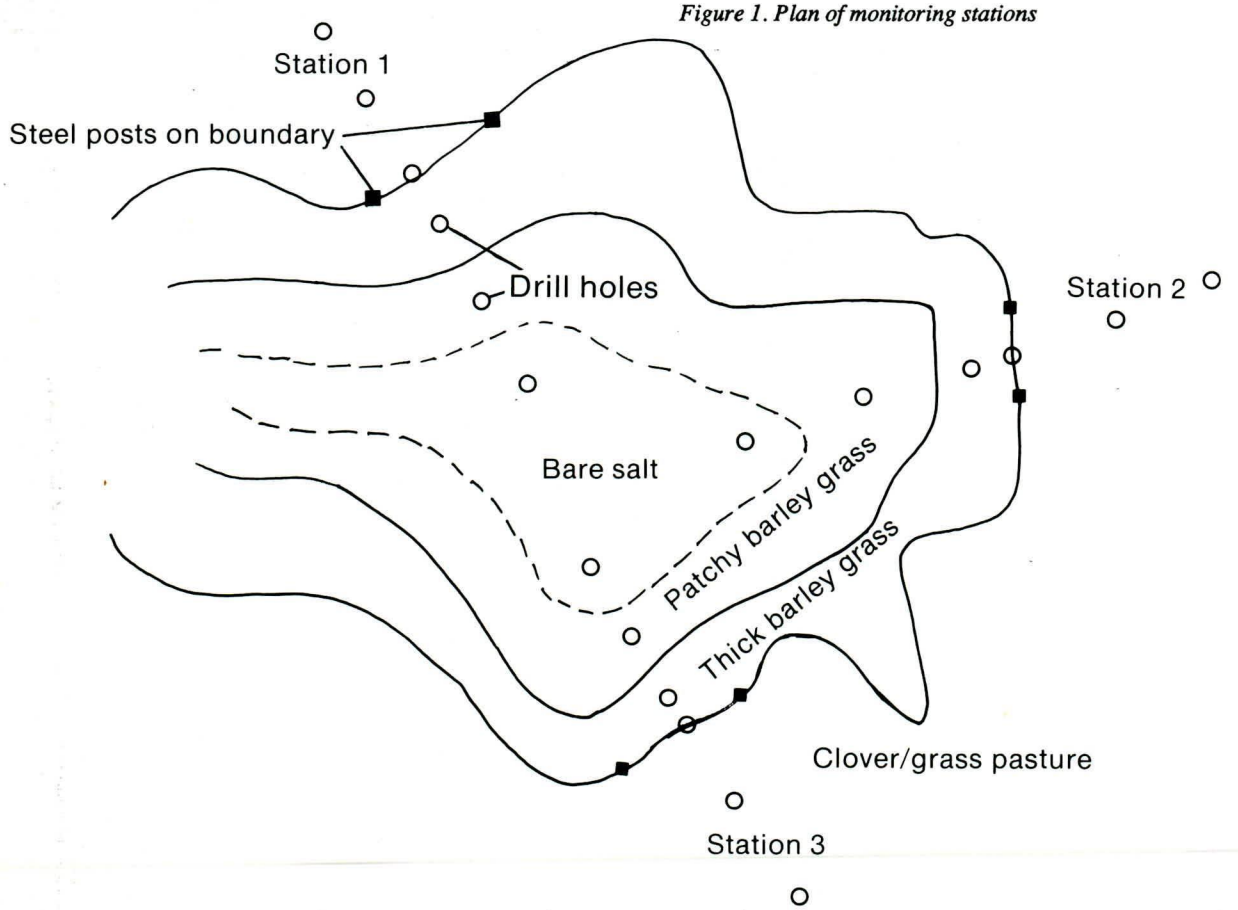
Regular soil sampling near the holes, every three years or so, will also confirm any changes in the soil salinity suggested by the vegetation. Take the samples at the same time of year in mid-summer, but not within three weeks of heavy rain.

Record the vegetation

Make a note each year of the vegetation type and density near each hole. It is likely to vary from bare soil (severely saline), through patchy barley grass (moderately saline) and thick barley grass (mildly saline) to clover/grass pasture (non-saline).

Using the worksheet on the back of this Farmnote is a convenient way to record the vegetation, as well as soil descriptions, salinity analyses and watertable depths.

Figure 1. Plan of monitoring stations



Measure the depth to the saline watertable

After drilling, leave the holes for at least three weeks before measuring the depth to the watertable from the top of the pipe. Subtract the height of the pipe above the ground surface to calculate the depth to the watertable below the ground surface.

Use a metric tape measure with a small wash basin plug wired on the end to detect the water surface by sound. Alternatively, use a tape and 'plopper' device, as described in Farmnote No. 53/90.

If no water is detected in a 2.0 m deep hole, it is unlikely that the land is in immediate danger of salt encroachment. Capillary rise (wick action) of saline water to the soil surface only operates from watertables that are 2.0 m deep or shallower in most soil types.

If the watertable is 1.5 to 2.0 m below ground level, the soil surface must be considered at risk. With depth to watertable less than 1.5 m there may well be indications of salt on the surface.

With the watertable at 1.0 m or less, salting is practically inevitable. In the worst cases, the watertable level in the pipe may rise above ground level, indicating upwards pressure in the watertable.

Interpretation of results

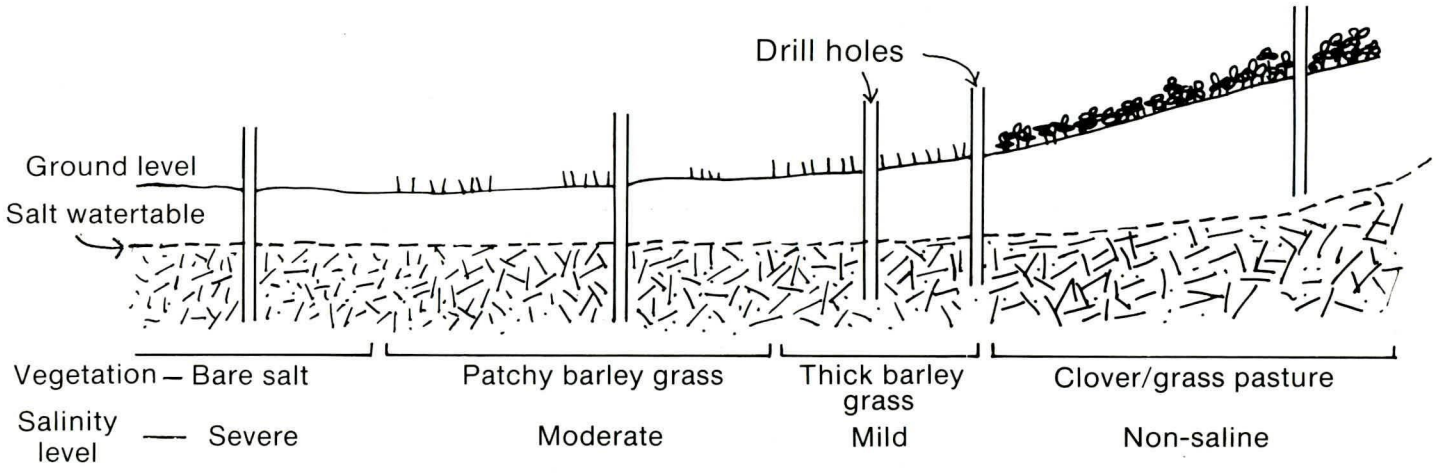
You have definite evidence of a worsening situation and of its rate of change, if, over a period of years:

- the watertable levels in spring and summer are rising;
- the clover/barley grass boundary is moving outwards; and
- topsoil salinity levels are increasing.

However, you have evidence of a stable situation *under the present climatic and management regime*, if the watertable levels, clover/barley grass boundaries and topsoil salinities are not changing.

Adopting this monitoring system will enable you to concentrate your concern and action where salt encroachment is most significant.

Figure 2. Longitudinal section of one monitoring station



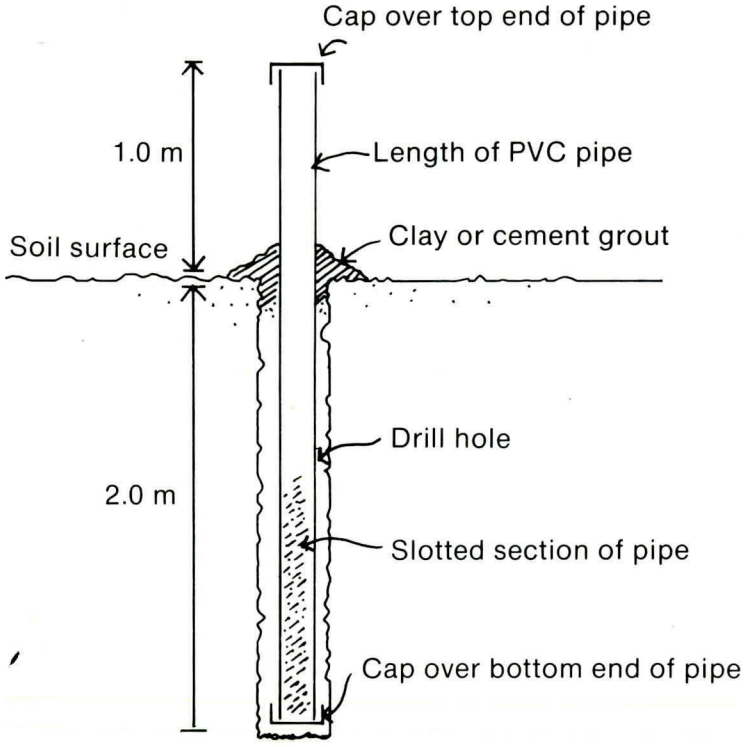


Figure 3. Cross section of drill hole

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Saltland Monitoring Stations

Name _____ Date drilled _____

District _____ Date measured _____

Telephone _____

Site No.	Hole No.	Depth cm	Vegetation cover	Topsil texture	Topsoil depth cm	Topsoil salinity mS/m	Ground water salinity mS/m	Watertable depth cm			Comments e.g. non-saline, mild salinity moderate salinity, severe salinity
								Date 1	Date 2	Date 3	

Site diagram

SELECTING THE CORRECT TREE VARIETIES - Brian Lloyd

Vital Questions

When choosing varieties of trees to plant on your farm, three vital questions need to be answered -

Why?:

Why are you planting trees? Choose tree varieties with the correct characteristics to suit your intended purpose, e.g.

- wind erosion control
- waterlogging control
- salinity control
- stock shelter
- commercial production (after considering future markets etc)
- nature conservation
- aesthetics, etc

Where?:

Where in the landscape do you intend to plant these trees? Choose tree varieties that are suited to the environment you will be planting them into.

Consider:

- soil
- shade
- drainage
- rainfall, etc

What?: Use nursery catalogues, reference books etc as a guide.

Consider:

- purpose
- soil
- climate
- position in landscape
- growth habit
- mature size

Best results will be achieved by planning a tree planting program and incorporating it into the overall farm plan.

This is vital, as your trees will outlast a lot of other farm improvements such as fences etc. You must get it right, then you can reap the benefits.

"Golden Rules"

A few general "golden rules" must be considered prior to choosing your varieties.

1. **Rainfall**

Rainfall is critical. Unless you have a very special case (e.g. a large freshwater seep), select trees from similar rainfall zones to your planting site or lesser rainfall zone.

e.g. if you are in a 450mm annual rainfall zone, plant trees suited to 450mm or less of rainfall. Don't plant a tree suited to a 900mm rainfall zone. Trees suited to a higher rainfall zone may survive for a few years but when their water usage peaks, they may well die if their annual moisture needs are not met.

2. **Soils**

Soils are also a very important consideration. Go to the planting site and dig a hole with a post hole digger. How deep to clay? How deep is that deep sand? Basically, find out what type of soil it is. You don't need to be an expert. Most nursery tree selection lists refer to light or heavy loams, clays, gravels or sand.

Some nursery tree selection lists are very useful, as they also list preferred rainfall, mature height, growth habit, uses and a general description.

3. **Local Native Species**

Try and replant back the local native species if suitable to requirements. By local native species, I refer to local remnant vegetation, not mature plantings of trees of origins unknown.

* They are more suited to the local rainfall, insects etc.
* Planting them perpetuates the local species.
* Use local seed sources if possible - there are subtle variations between the same species from different areas.
* When using seed from local species ensure the trees you collect seed from are from similar soil types.

However, local native species may not be suitable if the environment has changed e.g. salt encroachment.

To get trees from local seed there are three possibilities:

- Collect your own seed and get someone else to grow it, (e.g. tree nursery).
- Collect and grow you own seed. Several farmers are doing this now and it is not as hard as it sounds.
- Collect and direct seed your own seed.

(For information on seed collection and direct seeding, contact me at this office).

4. **Avoid Monocultures**

These are plantations of the one species of tree only. Past experience has shown that if the one species you plant happens to be susceptible to a particular insect, spray drift etc, severe damage can be done to the stand.

The "Best Bet" option is a suitable mix of varieties (commercial plantations are an exception).

5. **Plan**

PLAN where the trees are to go. They will be there for a long time (if not forever!). Spur of the moment plantings can be a major nuisance. If you plant a major line of trees in the wrong spot you have two options:

- develop the farm around it, then everything else is also in an awkward spot.
- pull them out, which makes it all a waste of time, money and effort.

If you develop a tree planting plan (ideally as a part of a whole farmplan) then the essential pre-planting tasks can be comfortably achieved, e.g.

- deep ripping on the contour at least 40 cm deep, and preferably one year prior to planting.
- mounding in waterlogged or salt affected sites.
- drainage of waterlogged or salt affected areas to prevent a poor survival rate.
- good weed control, and so on.

(Note: I can supply further information on establishment technique if requested).
Also, plan your species well in advance. Don't use cheaper surplus nursery stock if these 'bargain' varieties are not suited to your intentions.

Some Of The Many Uses for Farm Trees

Some specific reasons for planting trees are listed below with some suggested species. **NOTE** however, there are often many more species equally suited to the task.

* Windbreaks

The basic design must extend to ground level to prevent increased turbulence, hence tunneling. Dense foliage gives a poor windbreak due to increase turbulence. Foliage needs to be 35% - 45% permeable. Fencing is essential.

The profile can either be:

- 2 rows of tall trees that keep foliage to the ground, or
- 4 rows: 2 inner rows of taller trees that shed their lower limbs and 2 outer rows of shorter trees that maintain their foliage to ground level.
- 3 rows: short, medium and tall species providing a wedge-shaped profile. Shorter species should be on the northern side so they are not shaded out.

The double rows prevent a gap in the windbreak (and wind tunneling) should one tree die, whilst another is planted in its place.

Permanent fencing beyond the extremity of where lower branches will grow is important in windbreaks so grazing of lower branches does not produce a wind tunnel. Thick foliage in the lower storey can also help out-compete grasses and this reduces the fire hazard.

Some of the many species include:

Varieties That Retain Foliage To Ground Level	Varieties That Shed Their Lower Branches
Light Soil:	**Light Soil:**
E. cladocalyx var nana (Dwarf Sugar Gum) *E. platypus var heterophylla* (Coastal Moort) *Pinus pinaster* (Maritime Pine)	*E. camaldulensis* (River Red Gum) *E. cladocalyx* (Sugar Gum)
Heavy Soil:	**Heavy Soil:**
Casuarina obesa (Swamp Oak) *E. platypus* (Moort)	*E. kondininensis* (Kondinin Blackbutt) *E. dundasii* (Dundas Blackbutt) *E. myriadena* (Snap and Rattle) formerly *E. gracilis*

(Note: I can provide further information on windbreaks if requested)

Gaps in windbreaks should be avoided as wind speed is increased through these gaps. Replant deaths as soon as possible. If access is needed through the windbreak, form the track diagonally through the windbreak and not aligned with prevailing winds.

If windbreaks finish in an open area, the plantings at the end should either be thinned out or progressively shorter species of trees used. These measures will gradually merge windspeeds again.

*** Salt Revegetation**

Firstly, the degree to which salt has affected the site must be determined:

An approximate classification is as follows:

- Mild: Thick barley grass
- Moderate: Patchy barley grass
- Severe: Bare ground

On Severe Sites:

These are fairly difficult areas to get trees growing on initially. The best strategy is to fence, drain and try small trial areas of samphire, puccinellia, etc after a light scarify. Some successes have been reported with various Tamarisks and *Melaleuca thyioides*. More varieties can be introduced at a later date as the site improves.

On Moderate Sites:

The suggested sequence radiating out from the salt is:

Melaleuca cuticularis (Salt Water Paperbark)
Casuarina obesa (Swamp Oak)
E. sargentii (Salt River Gum)
E. kondininensis (Kondinin Blackbutt)
E. occidentalis (Flat Topped Yate)
E. spathulata (Swamp Mallet)

There has also been some successes with the newer salt tolerant *E. Camaldulensis* clone varieties.

On Mild Sites:

All the above plus -

E. loxophleba (York Gum)
E. platypus (Moort)
E. camaldulensis (River Red Gum)
Acacia saligna

With saltland plantings, do not get carried away with the high water using species. Part of the reason these plants named are salt tolerant is that they do not uptake masses of salt water. Many "high water users" such as *E. globulus* (Tasmanian Blue Gum) are not salt tolerant.

Salt tolerant trees do use considerable amounts of water. C.S.I.R.O. trials at Popanyinning (a 420 mm rainfall zone) revealed the following water use data when the trees were 27 months old:-

Species	Common Name	Water Use (Litres/Day)
E. occidentalis	Flat Topped Yate	20
E. loxophleba	York Gum	20
E. camaldulensis	River Red Gum	17

The point demonstrated by this chart is that these trees, although not classed as "high water users", are salt tolerant and still use considerable water.

* **Fodder**

Ceratonia siliqua (Carob - must have the male and female trees)
Chamaecytisus palmensis (Tagasaste - on lighter soils. Also for recharge area management)
Acacia saligna in conjunction with other salt tolerant fodder plantings.

* **Wood Production**

Pinus radiata (Monterey Pine) - high rainfall, good soil (loam)
Pinus pinaster (Maritime Pine) - lower rainfall, poorer soil (sandy loam)

Refer C.A.L.M. Publication 2/87 for planting limits.

* **Pulpwood**

E. globulus (Tasmanian Blue Gum)
E. botryoides (Bangalay or False Mahogany)
E. saligna (Sydney Blue Gum)

All these for higher rainfall areas.

* **Small Timber**

E. loxophleba (York Gum)
E. wandoo (White Gum)
E. astringens (Brown Mallet)
E. spathulata (Swamp Mallet)
E. occidentalis (Flat Topped Yate)
Acacia acuminata (Jam)

Note: *A. acuminata* is one of the suitable hosts for sandalwood, so a planting of both would have a dual function.

* **Firewood**

E. cladocalyx (Sugar Gum)
E. astringens (Brown Mallet)
E. wandoo (White Gum)

* **Shade**

E. wandoo (White Gum)
(White gum bark is unpalatable if sheep must be allowed near it. For a low wind erosion risk site only)
E. kondininensis (Kondinin Blackbutt)
E. occidentalis (Flat Topped Yate)

* **Soil Stabilisation**

E. rudis (Flooded Gum): for gully heads and creek banks.
Acacia saligna: has extensive roots and is a fast grower.

* **Oil Production**

E. spathulata (Swamp Mallet): investigate the market before embarking on this one.

* **Wildlife Attraction**

Grevilleas, Callistemons, Banksias, Acacias, Eucalypts etc. Attractive nectar-producing ones are best. Fencing is important to allow an understorey to grow. Some farmers have observed noticeable insect pest reductions after attracting native birds with such plantings.

On a remnant vegetation site, it is important not to 'clean-up' the site, as old logs, rock-piles etc can also harbour wildlife. It is also advisable to link remnant vegetation with shelterbelts to allow wildlife corridors between stands.

* **Fire Protection**

Trees selected for fire prone areas should be able to either:

- be resistant to burning
- regrow if burned (i.e. most native species)

Leaves of deciduous tress generally have a high moisture content and are difficult to ignite. Other trees whose leaves have a high moisture content and a low flammable resin and oil content are also suited to this purpose. These include *Schinus molle* (Pepper Tree), *Chamaecytisus palmensis* (Tagasaste), *Brachychiton sp.* (Kurrajongs) and most oaks.

Trees and plants that store salts in their leaves are also fire retardant e.g. Tamarisks and *Atriplex sp* (saltbush). Avoid using trees with ribbon bark as embers can blow off causing spotfires. Trees such as *E. salmonophloia* (Salmon Gum) and *E. cladocalyx* (Sugar Gum) retard grass growth underneath them, and as such can retard the advance of a grass fire in "Trees for Farms."

Windbreaks can be established at appropriate spacings to slow the speed of an advancing fire. Refer to the notes on windbreaks in "Trees for Farms."

In summation, there is a huge range of tree and shrub species for a large variety of uses. Thinking, planning and seeking advice will yield the best results.

Reading Material:

There are many books on trees. A small sample include:

"Trees for Farms", - W.A. Dept of Agriculture, Bulletin 4206
"A Guide to Eucalypts", - Brooker and Klenig
"Eucalypts of Western Australia, - C.A. Gardner
"Growing Trees on Western Australian Wheatbelt Farms", - K. Newby
"Eucalypts of the Western Australian Goldfields and the Adjacent Wheatbelt",
- G.M. Chippendale

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Department of Agriculture
Western Australia

Trees for farms

Compiled by officers of the
Department of Agriculture
and the
Department of Conservation and
Land Management

Editor K.M.W. Howes

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Department of Agriculture
Western Australia

Trees for farms

Preface (2nd Edition)

In this 'Decade of Landcare', tree planting on farms is a major objective. But long before 'Plant trees' became the catchphrase, farmers were aware of the benefits to be gained from tree planting—reduced salinization, reduced erosion and reduced flows of nutrients into waterways.

In recent years there has also been a growing awareness of the direct financial benefits that can be derived from plantations. Timber is becoming more valuable and farmers are now contributing significantly to future timber and woodchip supplies for Australia.

This Bulletin is an updated and revised edition of a book produced in 1986 under the aegis of the Boyup Brook Soil Conservation District Committee. Its aim is to provide prospective tree planters, whether they are doing it for reasons of beautification, conservation or commercial use, with a 'recipe book' of how to establish trees.

There is some repetition between individual chapters but this is intentional. Each chapter is meant to stand alone, without irritating cross-referencing.

Acknowledgements

This Bulletin is heavily dependent on contributions from officers or former officers of the Departments of Agriculture and Conservation and Land Management.

Individual chapters do not carry a by-line but I would like to acknowledge the invaluable input (either directly or by my plagiarism of their writings from elsewhere) by:

Ken Angel[1], David Bicknell[2], Peter Eckersley[1], Roger Edmiston[2], Leon English[1], Malcolm Green[1], Michael Grimm[1], Alec Hart[2], Kerry Hawley[1], John Humphreys[2], Phil Michael[1], Tim Negus[1], Gerry Parlevleit[1], Alan Thamo (Small Tree Farm, Balingup), Alan Walker[2] and Peter Whale[1].

(1) Officer or previously officer of the Department of Agriculture.
(2) Officer or previously officer of the Department of Conservation and Land Management.

K.M. W. Howes
Editor

Native seed collection

Introduction

This chapter outlines techniques and equipment required to collect seed from the major genera of local flora. Seed can be collected for immediate use or for storage and future use.

Permits are required if you intend to collect seed for commercial purposes or from areas of Crown land. Collection is prohibited in National Parks and gazetted rare species cannot be collected anywhere. Contact the Department of Conservation and Land Management for full details.

Flowers and seeds

Potentially good seed crops can be identified by recording where patches of the desired species is flowering heavily.

Provided fertilization has taken place, seed will begin to mature in the fruit. Development of a good seed crop following heavy flowering can be upset by:

- sustained cold, windy weather;
- sudden drought;
- lack of birds or insects to complete pollination.

Seed collection

Fresh seed is more viable than old, stored seed. Therefore match the amount you collect to your short-term needs. A few ripe fruit will often suffice.

Before collecting any fruit be sure that you know:

- the time(s) of year when ripe fruit can be picked;
- what ripe fruit looks like.

The fruit of the various species can be divided into two major groups:

- species with persistent woody capsules or fruit;
- species which shed their seed annually.

However, even within a genus there can be considerable variability.

Species with persistent woody capsules or fruit

Some species (for example species from the genera *Banksia, Callistemon, Hakea, Melaleuca* and *Eucalyptus*) retain woody capsules or fruit on the parent plant for a long time and release their seed after some stimulus such as fire or the plant's death.

With the Myrtaceae family (eucalypts, melaleucas, callistemon) the first indication of ripeness is the dark colour and woody texture of the fruit. In addition, on eucalypts and other Myrtaceae with large fruit, the valves - at the top of the fruit - turn brown and begin to separate when the fruit is ripe. Most of the Myrtaceae family carry a series of fruit crops at different stages of ripeness and the ripe fruit are further back on the branch. Check the valves are not already open and seed dispersed.

For the majority of these species, seed can be collected nearly all year. However, it is advisable to collect during the warmer months when fruit can be air dried to extract the seed.

Species which shed seed annually

Species which shed all their seed annually, do so after a relatively quick ripening period and the seed itself is shed over a relatively short period of time. Examples include many of the understorey species such as the native legumes (e.g. acacias and kennedias).

Most of this category, depending on the species, shed their seed between October and December. As the green pod changes towards brown and the texture becomes drier and more brittle, the seed matures. At this stage they must be watched carefully as one hot day in early summer can 'pop' most of the seed on the bushes.

Collection

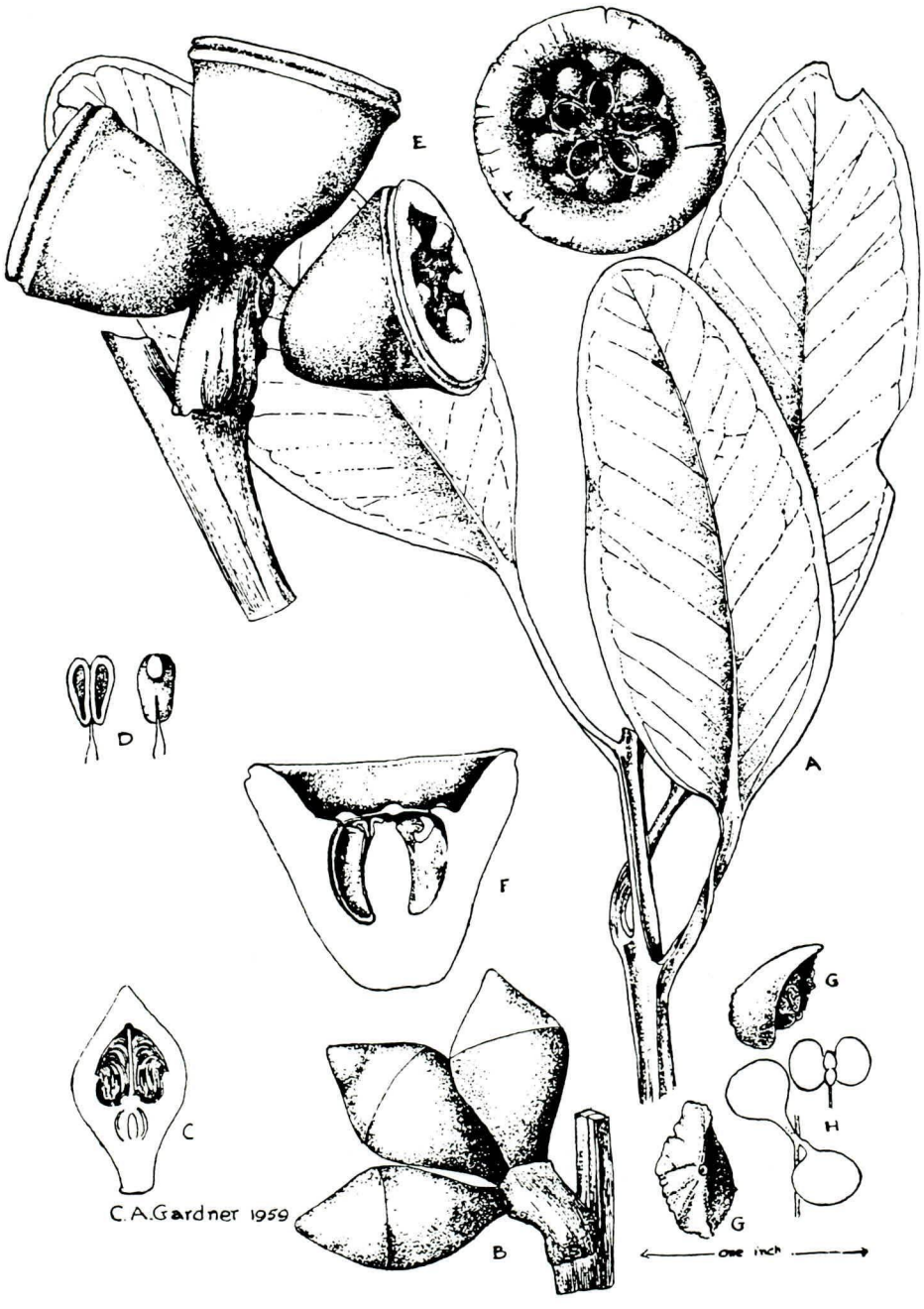
When the fruit is ripe, either individual fruits or heavily laden small branches can be removed, making sure the minimum of damage is done to the parent plants. Collect fruit off the tree because those on the ground are generally empty or will have been attacked by insects or fungi. Place in bags (either paper, cloth or wheatbags), plastic rubbish bins or in the back of a ute for transport to a central area for the extraction of the seed. Do not use plastic bags.

Equipment and collection techniques

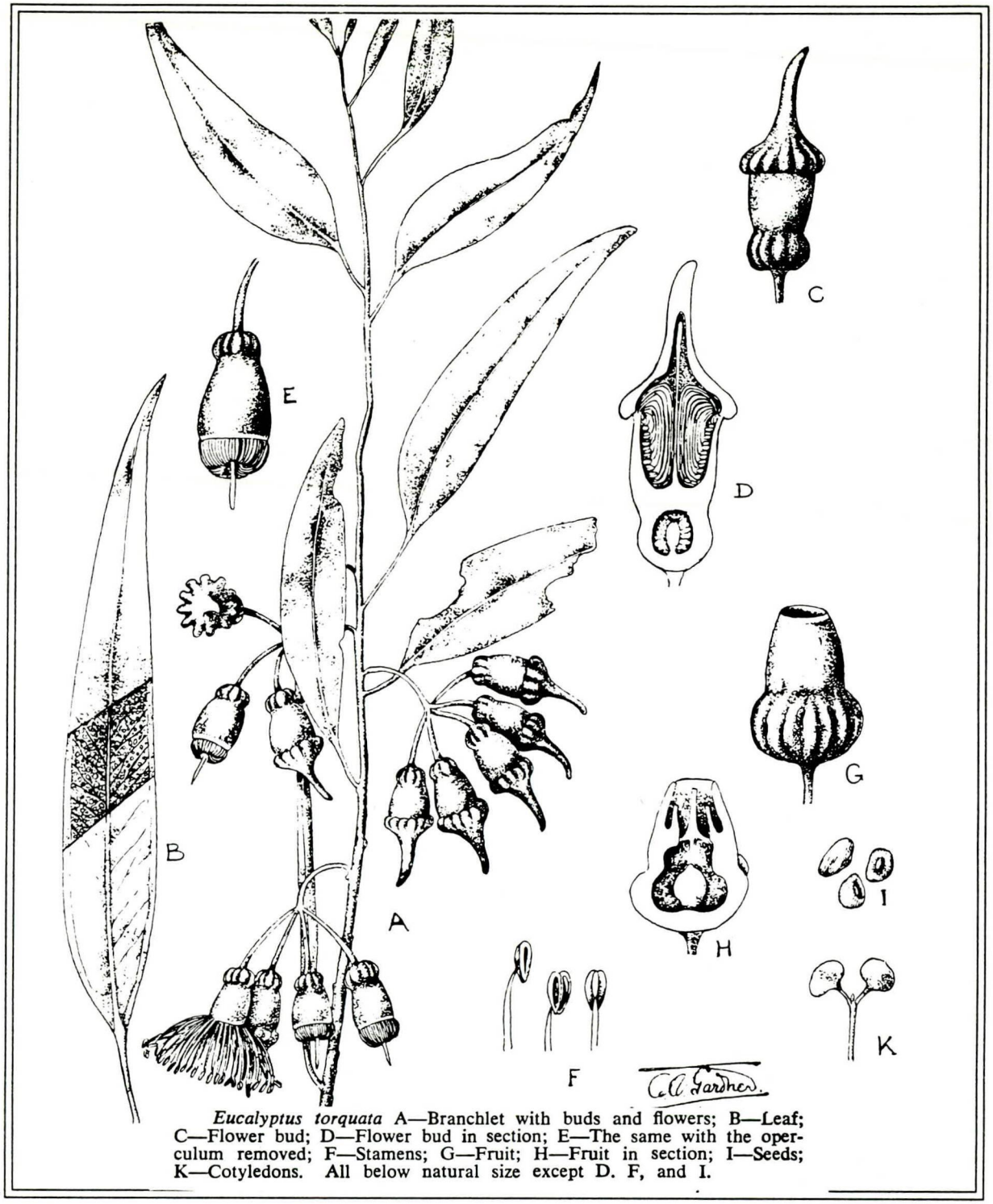
The techniques and equipment used to collect the ripe fruit depends on the amount of seed required and the height of the fruit above the ground. Fruit from the majority of low growing species is relatively easy to collect using secateurs or pruning equipment available in most hardware stores. Gloves may be required.

Tall trees require special equipment and techniques to avoid destroying the parent plants. These include:

- extendable pole pruners or pole saws (to 3 m in length), and/or a sturdy, stable ladder brings the crowns of many smaller trees and shrubs into reach;
- throwing a rope over small branches and snapping them off. For the serious collector a 'commando-saw', a length of flexible saw with ropes on either end, can be used to a height of 10 m. This method requires



Eucalyptus preissiana A—Branchlet with leaves; B—Flower buds; C—Section through flower bud; D—Anthers; E—Fruits; F—Section of fruit; G—Seeds; H—Expanded cotyledons.



Eucalyptus torquata A—Branchlet with buds and flowers; B—Leaf; C—Flower bud; D—Flower bud in section; E—The same with the operculum removed; F—Stamens; G—Fruit; H—Fruit in section; I—Seeds; K—Cotyledons. All below natural size except D. F, and I.

some skill in positioning the saw. Horizontal branches are easier to saw than those with acute angles to the tree;

- collecting from very high trees is hazardous and should only be done by experienced people who have proper safety equipment.

Extraction

The method used to separate seed from the fruit of various native species depends on:

(i) the climatic conditions which prevail where seed is to be extracted;
(ii) the characteristics of the seed or fruit of each species; and
(iii) the size of the collection.

The most economic methods of extraction for most species are:

(a) air drying, particularly in the drier areas of Western Australia and during the warmer months of the year;
(b) oven extraction, in areas of high humidity.

Air drying

Large collections

Place large collections of fruit or branches on a canvas tarpaulin or plastic sheets in a well-ventilated position of partial sunshine (e.g. in a shearing shed) until the seed is shed. In warm weather direct sunshine will overheat the fruit and kill much of the seed. Most species will shed their seed within 7 to 21 days. Wait until most of the fruit has opened or split, then shake the branches to dislodge all remaining seed. Remove empty fruit and branches. Put the seed in paper or cloth bags.

Small collections

Place the fruit in ventilated containers such as paper or cloth bags. An open plastic container can be used provided capsules are spread out evenly over two to three layers, thus allowing for air to circulate between the fruit.

Oven drying

When humidity is high, put lots of capsules into strong paper bags before placing in a kitchen stove at about 60°C. The door of the oven should be partially open, depending on initial heat of the oven. Capsules can be left overnight and removed in the morning.

For extraction of bulk collection in humid localities large drying ovens are required.

Special treatments

Banksia

Place the cones in an oven at 80 to 90°C or scorch the cones in an open fire. Immediately after the heat treatment submerge the cones in water. Allow to dry. If the follicles are open wide, vigorously jar the fruit to remove seeds. If follicles are still closed, repeat the procedure.

Dryandra and Hakea

Place the fruit in an oven at 80 to 90°C. The seed will be released if it is fully mature. Do not exceed these temperatures as high heat will damage the seed. Hakea species hold their typical black, winged seeds strongly within a woody fruit, which will require more than the usual drying time to release seed.

Some legumes

Some species of legumes such as carob beans and a few acacias hold their seeds tightly within their pods. It may be necessary to pass the acacia fruit through a hammer mill or, in the case of carobs, soak them in water before the seed can be separated. Screen the softened carob mass and dry the seed. An alternative is to soak the carob pods for 24 to 28 hours until the pod softens, then use a knife to open the pods and extract the seed.

Cleaning the seed

After extracting seed from the capsules or cones, some cleaning of the sample is desirable to remove fragments of leaf, small twigs, empty capsules or foreign matter such as dust and soil particles. The easiest way to remove these impurities is to sieve the sample through suitable screens.

Seed storage

Essential matters in seed storage are:

- moisture content;
- temperature of storage location;
- storage containers;
- insect infestation.

Moisture content

Generally, moisture contents should be between 4 to 8 per cent and stabilized. Under normal conditions air-drying and oven-drying extraction usually result in suitable seed moisture content. If in doubt, dry the seed further in a warm, shaded and dry area.

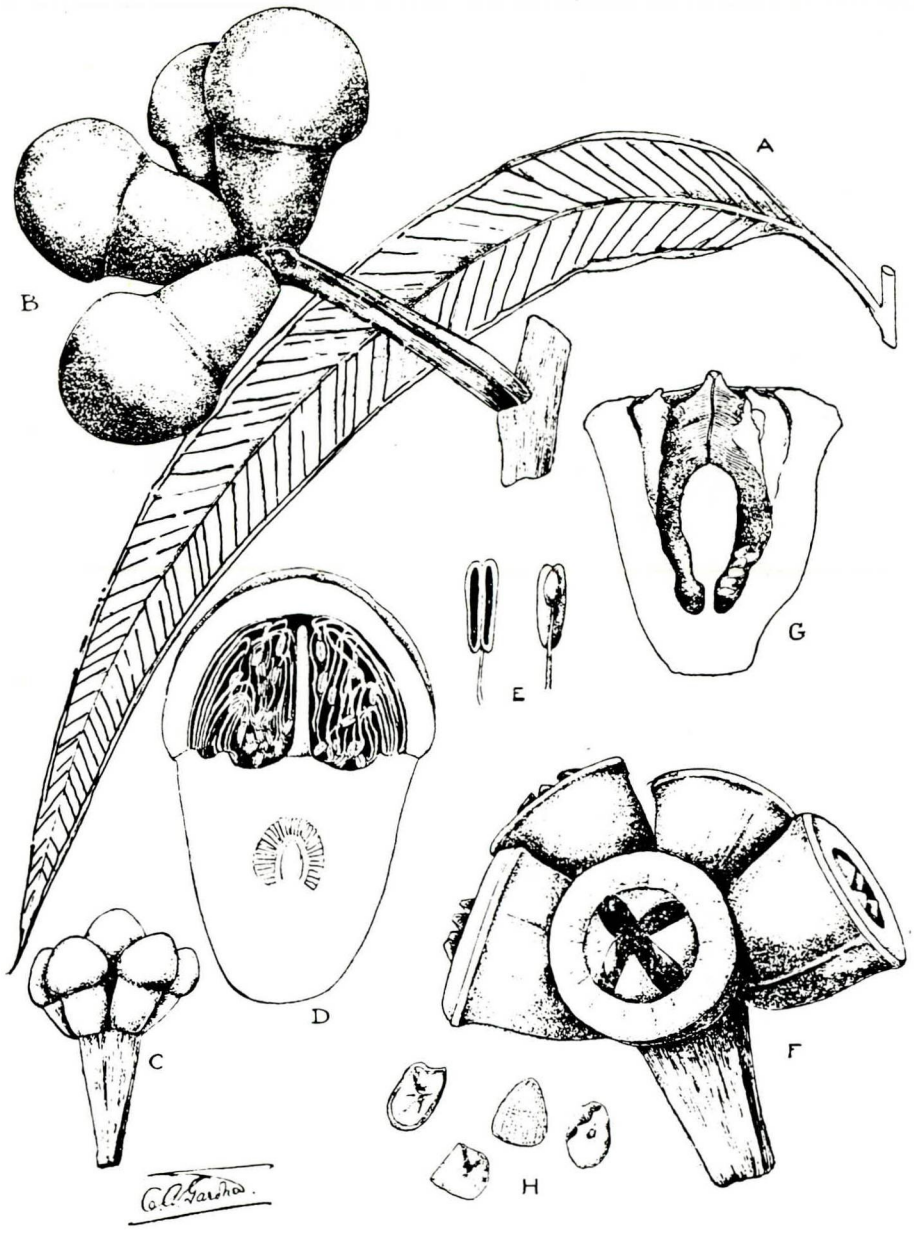
Storage temperature

Once seed has been placed in storage containers, it should be put in a cool and dry area where fluctuations of temperature and moisture are kept to a minimum.

Storage containers

Press-in lid tins or plastic jars with screw top lids ensure a good seal and minimize moisture content changes.

To minimize the amount of air in each container, fill to capacity with seed. The size range of containers available is wide and should be selected in keeping with the size of the collection.



Eucalyptus gomphocephala A—Leaf; B—Buds (x 1.5); C—Buds (x 0.5); D—Section of flower bud (x 2); E—Anthers (much enlarged); F—Fruits (x 1); G—Section of fruit (slightly enlarged); H—Seeds (much magnified).

Labelling seed lots is vital for later identification and should include species' name, date collected, locality details and seed viability results. Place a duplicate label inside with the seed, as the outside label can become defaced or lost.

Insect control

Insect control is important. The Department of Conservation and Land Management use 'Dryacide' to exterminate insect pests in seeds. However, this is only available in a minimum 15 kg bag. An alternative is to dust with an insecticide powder or a combined fungicide/insecticide powder available from most stores. A light application is all that is required. Check the stored seed lots frequently to monitor insect attack and moisture content changes.

Seed viability testing

Viability varies with age, storage conditions and with the maturity of the seed. Test the seed on collection and, if stored for some time, before use. With large seeds such as acacias use 30 seeds for testing. With fine seeds use a small pinch of seed. A small pinch of seed is about 0.2 g.

A simple procedure to test seed involves:

(a) placing a fine grained sponge on a saucer of water;
(b) placing or sprinkling the seed sample on the sponge;
(c) keeping the sponge moist and in a warm place at 20 to 25°C.

Viable seed will germinate in about 14 to 28 days. By simple calculation you can now determine the number of grams or kilograms of seed you will required to grow a certain number of plants.

Growing eucalypts from seed

Raising eucalypts from seed can be a rewarding and inexpensive method of producing a quantity of trees for shade, shelter or conservation. The Department of Conservation and Land Management has some excellent Information Notes on this subject.

Chaff and seed

The seeds of eucalypts vary greatly in size, ranging from 0.5 to 15 mm long and from 0.5 to 7 mm wide. In any single capsule, only a few seeds are fertile. The rest are unfertilized ovules known as chaff. It is difficult to distinguish between the two in most varieties of eucalypts, and allowances must be made for this chaff when sowing.

Soil moisture

The soil used for seed germination should be light textured - it can be a dark, surface sand or a sandy loam. If the local soil is heavy, mix it with equal parts of sand and compost. Strong manures should not be used, but a handful of a 50/50 mixture of blood and bone and potato manure E per barrow load of soil is beneficial.

Cover the seed with an open textured medium which is not inclined to compact. It can be sand, stone dust, vermiculite, peat moss, rotted sawdust, finely sieved compost or a mixture of any of these components.

Both the soil and the covering medium should be sterilized before use.

Sterilization

Soil sterilization destroys weed seeds and any harmful pathogens that may be present.

Commercially, steam or methyl-bromide gas are used to sterilize the soil, but in small programmes these methods are not practicable.

Heating the soil to 82°C on a metal tray over a fire is effective, but the main problem with this form of treatment is obtaining an even temperature throughout the medium when treating a reasonably large quantity of soil. Excessive heat can destroy the organic matter in the soil.

The most suitable method for small scale operations is sterilization with formalin. This product is readily obtainable and can be used for treating soil in containers or on open areas. Use one part of commercial formalin to 24 parts of water and sprinkle the solution on to the soil at 1.2 L/m^2. The soil is then watered to seal the surface and covered with a tarpaulin, plastic sheeting or bags for 48 hours. When dry enough, the soil is worked with implements (previously soaked in the solution) to assist the escape of formaldehyde gas. Plants and seeds can be grown in treated soil when no smell of formalin can be detected - usually in 10 to 14 days.

Other proprietary soil fumigants are available on the market. They are easy to apply and should be used according to instructions.

Take care not to re-contaminate the soil by using dirty tools, containers, or by bringing the medium into contact with untreated soil.

Containers

The type of container used for growing the tree is not important, but good drainage is essential. The choice will depend on availability and convenience, and can be either separate pots for each plant or boxes in which several seed are sown and the plants are pricked out into pots at a later stage.

Direct sowing in individual pots is recommended because the tree does not receive a check in its growth, as it does when transplanted from a seed box. An ideal size is the 10 cm square pot used in most nurseries, but small tins or terracotta pots can also be used. Peat pots are also available, and have the advantage that the pot does not have to be removed at planting out.

Preferably one type of container should be used for a sowing, otherwise they will dry at different rates and can cause problems with watering, and subsequent germination failure.

If using trays, a depth of 8 to 10 cm is ample.

Drainage holes should be made in tins and wooden trays. If the latter have spaces between the bottom boards, holes are not necessary. Broken clay pots, blue metal, gravel or cinders can all be used to assist drainage. If bottom watering is practised, the crocking material should have fines among the bulk to prevent the soil coming out.

The sterilized soil is placed in the container and firmed to within 14 mm of the rim.

Sowing time

The ideal temperature for germination of eucalypt seed is 20 to 25°C.

The main disadvantages with autumn sowing are the possibility of heavy rains which may wash the seed-covering away and the danger from frosts. Growth rates during the cold winter months will also be slow. However, in some localities autumn sowing can be an advantage.

Spring is the generally-accepted sowing time. After germination, the warm weather hastens growth and the plant will be an ideal size for setting out the following winter.

Sowing the seed

The two most important factors in successful seed germination are sowing depth and moisture. Sowing too deep will impair germination. Watering too lightly or too heavily can kill the seedling.

When sowing into individual pots, a small pinch of seed (allowing for chaff) is placed in the centre of the pot and firmed lightly with the finger so that the top of the seed is level with the soil surface. The seed is then covered. The recognized rule for depth of covering is twice the diameter of the seed at its narrowest section. This means that the covering thickness could range from 1 to 14 mm. Where light mediums such as vermiculite or peat moss are used, a thicker covering can be applied. When the seedlings are 2 to 5 cm high, they are thinned out leaving the strongest plant in each container.

Moisture requirements

Germinating seeds need high moisture levels - if the surface dries out the seed may die. Watering with a heavy spray can remove the surface covering, exposing the seed to drying. Bottom watering or covering the tray or containers with hessian helps to prevent this.

Bottom watering

The pots are placed in a flat container which is filled with water to half the depth of the seed container. Capillary action will carry the water to the surface, after which the pots should be removed or the water drained from the container.

Hessian

Hessian is soaked in water, allowed to drain, then placed carefully over the seed containers. If the containers have been correctly filled, the damp hessian should lie on the surface. Weights or wire pegs should be used to prevent the hessian blowing off. Light watering is then applied to the surface of the hessian. Daily inspections must be made so that the hessian can be removed as soon as the seed germinates. Frequent, light waterings are then applied.

A frame with a plastic covering can also be used to retain moisture in the surface, but it should be lifted every day or two to allow aeration.

The seed containers should be kept in partial shade until the plants are about 5 cm tall.

Broadscale direct seeding of trees

Introduction

Farmers recognize that two of the biggest threats to their livelihood are soil erosion and salinity. The placement of large numbers of trees in the rural landscape can alleviate these threats and at the same time enhance the aesthetic value of the country, provide natural habitat and connect corridors for birds and other wildlife. The problem has been the cost and time involved in planting and tending seedling trees.

Direct seeding may prove to be a practical way to establish very large numbers of trees on farms. Tree seed can be sown through a combine or a specialized direct seeder. Direct seeding machines are available to place a continuous single row, or blobs of seed along a line. Some machines can plant seedlings or seed, and produce a furrow or scraped area for weed control. Discuss these options with your tree adviser. Most of this article focuses on the use of a combine.

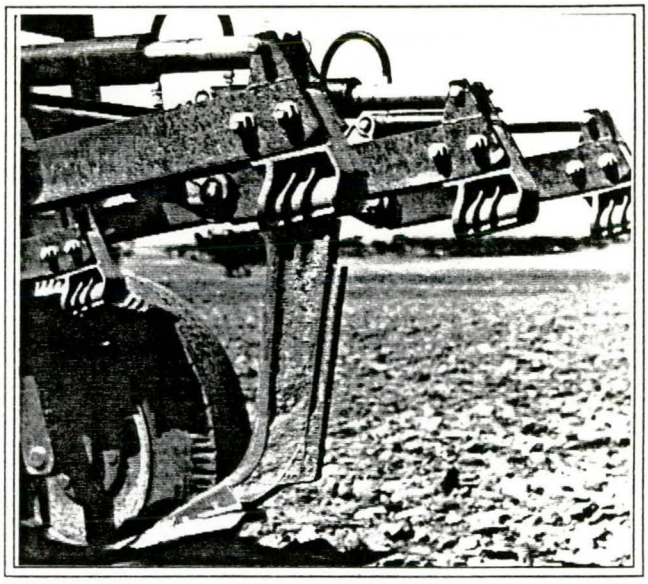
Direct-sown seed needs ideal conditions to germinate - that is, a series of soaking rains after sowing. Given this, and providing they are free of competition for moisture and nutrients, direct sown seedlings grow very rapidly in the first few months.

The elimination of weeds from the seed bed is essential as they will compete against the slower growing native species. Despite this, direct seeding is relatively cheap, simple and quick. There is no need to purchase any new machinery - a standard combine does the job. It takes (for example) only a few hours of work in ground preparation to establish a kilometre of trees. Also, direct seeding ensures the early development of a strong root system which removes the need for summer watering of young trees.

Ground preparation on old land

Land that has been cropped or pastured for years develops a compacted layer which young tree roots have difficulty penetrating. Deep ripping (40 to 100 cm deep) allows roots and moisture to penetrate deeper into the soil profile.

Ripping is best done in autumn or early winter in lines up to 1 m apart.



Deep ripping before seeding improves establishment, particularly on old land.

Weed control

Established farm land usually has a 'bank' of weed seeds in it. The elimination of competition from weeds is the most important factor in establishing trees by direct seeding. The aim is to have the ground absolutely weed free before sowing and control all weeds at least into the first summer after sowing.

This is best achieved on medium and heavy soils by multiple cultivation using a scarifier. It will need to be repeated at least three times so that successive germinations from the weed seed bank are killed. On sandy surfaced soils this continued cultivation will leave the prepared land susceptible to erosion. The risk can be lessened by sowing rows of a suitable cover crop to protect the seeded area.

Scalping off the top 5 to 7 cm of soil with a blade or road grader just before direct seeding removes the weed seed bank altogether and provides very effective weed control into the first summer. A very light cultivation to loosen the top soils is all that is required before seeding. Do not scalp shallow duplex soils where clay will be exposed once the overlying sand is removed, as very poor results have been achieved on exposed heavy soil types.

Chemical weed control

Cultivation or scalping can be supplemented with applications of contact herbicides such as glyphosate or paraquat/diquat before sowing. All residual herbicides appear to have a detrimental effect on the germination of tree seed.

Late germinating grasses can be, and must be, controlled with the selective grass herbicides (Fusilade® or Sertin®) sprayed, at recommended rates, over the top of germinating tree seedlings. Keep a close watch on grass weeds, particularly during the first eight weeks after sowing, and spray as soon as the problem is noticed.

Ground preparation on new land

Because there is no compacted soil, and no weed seed bank on newly cleared land, ripping and repeated cultivation are usually unnecessary. However, if the soils are shallow and over clay, ripping is beneficial. Otherwise, just lightly cultivate immediately before sowing and leave the soil as rough as possible. New land can be sown any time after the season has broken; the earlier the better.

Difficult sites

It is advisable to begin with the sites which are easier to establish; that is, well drained, sand or loam soils which are not salt affected.

Late germinating broad-leaved weeds

Sites with late germinating, aggressive broad-leaved weeds are a major problem, and should be avoided because we currently have no practical way of controlling them after the tree seed has germinated. Scalping can be used on such sites before sowing to remove the seed store; cultivation and chemical weed control have not proven successful. However, on most sites, broad-leaved weeds germinate early and can be controlled before sowing.

Heavy textured soils

'Surface-sealing' of clay soils makes direct seeding difficult and further research is required. Many of these soil types (salmon gum, red morrel areas) naturally had few trees per hectare and therefore using nursery raised stock can augment the natural cover.

Deep sands

Light sandy soils need protection to avoid sandblast and erosion by wind. A protecting crop of cereal must be planted either side of the direct sown tree strip on these soils. However, do not sow grasses with the trees because they will compete for moisture and eventually dominate the slower growing native species. Non-wetting sands present additional problems with direct seeding and unless these sands can be scalped off before sowing, direct seeding is not recommended for these sites.

Waterlogged/saline sites

Germinating seedlings will not survive if they are waterlogged, even for short periods of time and most species are very sensitive to saline conditions, particularly when young seedlings. Such areas are not recommended for direct seeding.

Steep slopes

Erodible slopes can be difficult to revegetate because seed is washed away with worked up topsoil. To avoid this the water can be harvested by building small crescent shaped banks across the flow of surface water; that is, on the contour. They should be short - say 10 m long - to avoid excessive overflows that may cause erosion. They can be constructed by using a backblade or roadgrader to bare strips 1 m or more wide. Move the top-soil downhill to form a curved bank that will hold water. In heavier soils the bare area should be ripped with a chisel plough to improve water penetration.

Water harvesting is used to increase the amount of available water to germinating plants as well as to provide a collection point of seed that would normally be washed away. It is especially valuable in the drier zones of the wheatbelt, and on erodible slopes.

Sowing

Old land should be seeded when good weed control has been achieved, usually in June or July. Trials have shown spring sowing (August or September) gives very poor germination and should only be contemplated on sites where winter waterlogging is a problem. Most eucalypt seed will germinate two to six weeks after sowing, however, during winter the small seedlings will remain dormant until soil temperatures increase. So seedlings often remain unobserved until as late as October or November.

Seed should be sown at 350 g/ha for new land and between 500 to 1000 g/ha for old country. This is mixed with super in a combine and applied at rate of 100 to 150 kg/ha going over the area twice to ensure complete coverage. Other 'bulking-up' agents used have been grade 2 vermiculite, graded sand, bran

A direct drilled windbreak.

flakes and chicken pellets. A 5 m wide combine over a distance of 2 km will cover 1 ha. The area to be sown must be scarified before sowing. When sowing, the combine tines are set just above ground level so the seed drops onto the rough ground surface. The hoses should preferably be disconnected from the boots.

For small seeded species such as most eucalypts, melaleucas and casuarinas the seed may be either left uncovered on the soil surface or very lightly covered by dragging wheat bags, a chain, brush or even a piece of carpet behind the combine. If the seed is buried even 1 cm below the surface, germination is severely affected.

However, large seeded species such as marri (*E. calophylla*), coastal blackbutt (*E. todtiana*) and all legume species (acacias, pea-flowered natives, tagasaste) germinate best when buried to a depth of about 1 cm. This can be achieved by pulling harrows behind the combine. If a mix of both small and large seeded species are to be sown on the one site, we suggest either they are sown separately (the large seeded species sown first) or if sown together, the best compromise would be surface sowing and lightly covering the seed using wheat bags or a chain pulled behind the combine.

Sometimes vibration will separate the seed and super, so it is advisable to have someone agitating the mix during sowing.

Germination can be significantly improved on sandy textured soils by compacting the site with the tractor tyres or a roller, immediately after sowing. Heavy textured soils should not be compacted.

Observation plots

Because of the small seedling size of many of our native species we suggest 'observation plots' be established i.e. two to three 50 cm square plots per site be permanently pegged, seeded by hand and carefully observed for seedlings. Once there is germination in the observation plots and you can recognize each species, seedlings can more readily be spotted over the whole site. Regular and close inspections of the observation plots will enable early identification of pest problems such as redlegged earth mite, lucerne flea, rutherglen bugs or grasshoppers. Seeded areas should be sprayed when the pests are seen in large numbers.

Protect the seedlings

Stock, wind and rabbits can all harm the young trees. The area must be fenced, or stock excluded from the paddock, for at least three years. Rabbits should be baited in co-operation with the Agriculture Protection Board.

Aftercare

If the plants are not vigorous at the start of the following season, a granulated NP (e.g. MAP) or NPK fertilizer application at 150 kg/ha will stimulate growth, especially on light soils.

Species selection

Use a mixture of at least four or five species to create a mixed windbreak of trees of various forms. This mixture will usually allow for any minor variation in soil types and topography. Select species native to the area, soil type and topographic position that are growing well in your district. If you wish to extend the range choose species from similar soil types and the same or lower rainfall (see Table 1).

Table 1. Eucalyptus species suitable for sowing at 350 g/ha on new land, and 500 g/ha on old established pasture or grazing land. (Rainfall - 400 to 600 mm)

Sand	Loam	Clayey-loam
E. camaldulensis	*E. camaldulensis*	*E. accedens*
E. cladocalyx v *nana*	*E. cladocalyx* v *nana*	*E. crebra*
E. gomphocephala	*E. gomphocephala*	*E. gardneri*
E. platypus v *heterophylla*	*E. platypus* v *heterophylla*	*E. spathulata*
*E. conferruminata** (x 1.5)	*E. gardneri*	*E. kondininensis*
E. lehmanii		
E. gardneri	*E. conferruminata*	*E. melliodora*
	E. lehmanii	
*E. todtiana** (x 6)	*E. crebra*	*E. occidentalis*
E. redunca v *melanophloia*	*E. sideroxylon*	*E. drummondii** (x 4)
	E. redunca v *melanophloia*	*E. sideroxylon*
	E. leucoxylon v *macrocarpa*	*E. platypus*
	E. megacornuta	*E. leucoxylon* v *macrocarpa*

* These species have known low germination rates, so seed quantities will need to be adjusted accordingly by the factors indicated.

Collecting seed

Collecting seed from your own farm or nearby has many distinct advantages. By collecting tree seed from a provenance close to the proposed direct seeding site you know what to expect when the seeds are sown. You will also be able to take advantage of easily harvested tree seed crops to reduce the cost of purchasing seed, and you have the guarantee of fresh seed. (See chapter on 'Native seed collection').

Germination testing

The viability of seed can vary enormously through factors such as age, storage temperature, maturity at collection or even the weather when the tree was flowering. A number of species are known to have inherent poor germination. This is no problem, provided that you are aware of poor germination and you make allowance in the amount of seed used. Seed purchased from reputable suppliers will have been tested before sale, seed you have collected yourself will have to be tested. Place a sponge pad (like Wettex) on a saucer and moisten it with water, spread a pinch of seed on the pad. Keep the pad moist and in a warm (20 to 25°C) position. Most viable seed will germinate within a fortnight under these conditions. A pinch is about 0.2 g and the benchmark is 100 germinants per gram. If you get less than 20 germinants in your pinch you should adjust the amount of seed used in the mix.

More information

This article was compiled from limited experience on research plots. The CALM Rural Advisory Service is keen to hear of any problems, successes or anomalies so that we can form a clearer picture of how direct-seeding works. Similarly, if you require more information to get started, contact an advisory officer at any of the locations below:

State Operations Headquarters

Como: (09) 367 0333

Bunbury: (097) 25 4300

Esperance (090) 71 2088

Narrogin (098) 81 1113

Tree planter's guide

Many farmers are now planting trees to control salinity and erosion, alleviate waterlogging, for shade and shelter or simply for aesthetic reasons.

Beware that you don't bite off more than you can chew. If you try and plant too many at your first attempt, and have inadequate preparation and poor aftercare, many of the trees will die. You may then be reluctant to spend time and money on further plantings.

Planning the planting programme

First draw up a firm plan - your local Department of Agriculture adviser can help with this.

Mark the following areas on your plan or on an aerial photograph:

- areas prone to erosion;
- non-wetting soils;
- seasonally flooded areas;
- seepage areas;
- saline areas;
- existing native vegetation;
- areas of tree decline;
- non-productive areas.

Within these boundaries mark areas requiring urgent treatment and then set priorities, bearing in mind realistic limitations of both time and money on what can be planted and tended each year.

Before planting any trees, carry out major works, such as relocation of fences, drainage lines and contour banks, which may conflict with the planting programmes. You will also need to take account of the direction of prevailing winds and other environmental factors.

Species selection

The species selected will depend on what you are trying to achieve. For example, if trees are being planted in salt prone areas, plant salt tolerant species. Shelterbelts require trees with foliage extending down close to ground level. (For windbreaks you can achieve the same result by planting small trees and shrubs between taller trees.)

Details of species are given elsewhere in this book. Advice is also available from CALM and the Department of Agriculture.

Before deciding on exotic species for the area check the potential of the local species. These species have developed under the climatic conditions of the area and are therefore well adapted. Frequently, local species are not considered suitable because of their slow growth rates. While this is true for some species, most species grown under cultivated conditions, with fertilizer and exclusion of weed competition, respond with much faster growth rates.

If the local species are not satisfactory then choose species which grow in similar soil types to your own and under similar or lower rainfall. Trees which grow in lower rainfall should be more drought tolerant than existing native species.

Ordering trees

Most nurseries seed their trees in November-December for sale the following winter. If orders, particularly large ones, are placed around seeding time the order can be filled. Delays in ordering will reduce your chances of getting the species you have decided to plant.

Size of stock

The seven to eight month seedling is ideal for establishment under natural rainfall or lower watering regimes. Most farm tree nurseries supply this type of seedling.

Under natural conditions trees establish themselves by first developing a deep root system to tap soil moisture. Pot grown plants cannot do this and suffer water stress when planted out. It is unwise to buy 'advanced stock' since the large foliage area on such plants puts them under severe moisture stress and the chance of successful establishment without frequent watering is minimal.

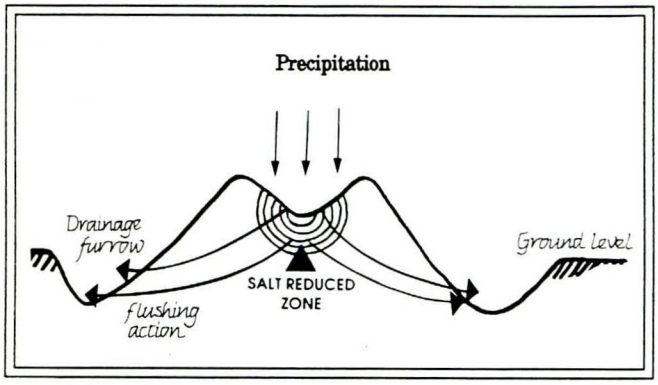
Another problem with advanced eucalypt stock is that the tap root will curl if left in the container for too long. After planting, the tree grows and the roots thicken. A restriction develops which can result in a severe setback or even strangulation of the tree. It can also make the tree prone to windthrow.

Preparing the site

Mechanical weed control

The elimination of weed competition with the young trees is critical to their survival in the first year following planting.

Removing the top 5 to 7 cm of soil with a grader removes the weed seed bank. (Note - do not use this technique on shallow duplex soils where clay will be exposed after removing the shallow top soil.)



Cross-section of a mound showing principle of salt reduction.

Ripping

Ripping is essential for heavy soils and is strongly recommended for all planting sites.

The depth of ripping is dependent on machinery, but should be to a minimum of 45 cm and preferably to 1 m. If possible rip during the summer months.

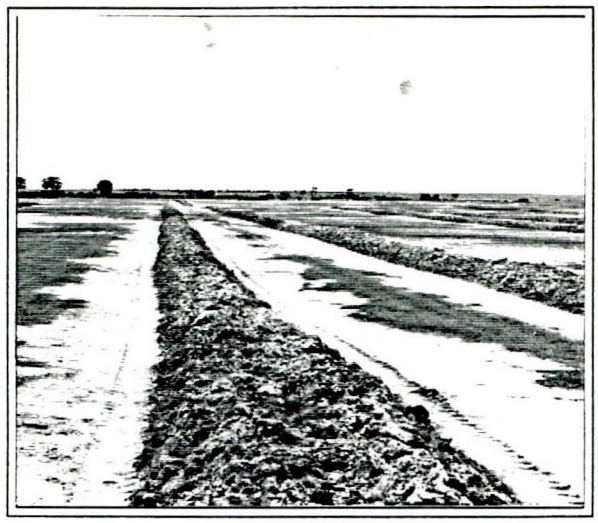
At least one but preferably three lines are ripped for each row of trees, and the trees are planted in the centre ripline. In sandy soils a single ripline will suffice. Multiple riplines should be spaced the depth of penetration apart.

Ripping should be on the contour, but if ripping has to be carried out down a slope, lift the ripper at various stages, depending on slope. Alternatively, rip and cross rip at the point of planting to prevent moisture running to the end of the row or erosion will occur. Ripping will more than compensate for the added cost by providing faster and healthier growth and reducing the need for summer watering.

Mounding

Young trees in saturated soil will die. Therefore do not plant early in low-lying areas where flooding can be a problem by the end of winter.

On such sites mounding will be necessary. After ripping, mounds can be made by using two opposing discs or a blade. On saline sites it is better to spread the discs to form a mound with a dished centre. The dished centre will concentrate the winter rains and increase the leaching of any salts.



Mounds thrown up on salt-affected land ready for planting.

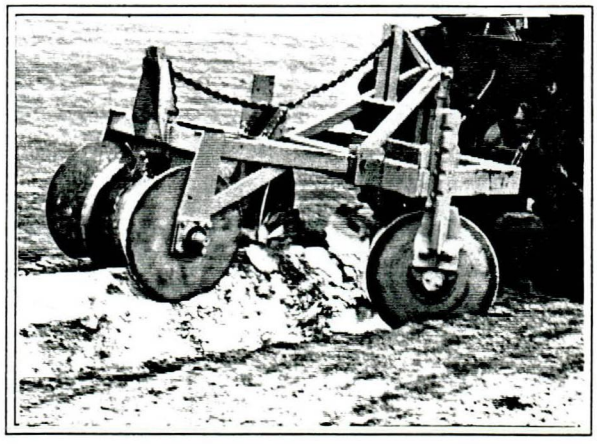
Water harvesting

In areas of low rainfall water harvesting techniques will accumulate rainfall and enhance the chances of establishment. One method is to grade the surface soil along the contour, at an angle, pushing the soil into an embankment. Water will pond behind this bank, and if the trees are planted in the riplines on the slope at the margin of the ponded water the chance of successful establishment is increased.

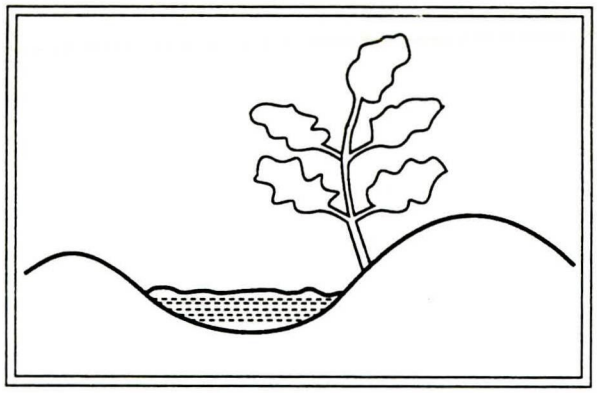
Pitting, another water harvesting technique, is an abbreviated form of furrow-lining. Individual niches approximately 2 m long and 1 m wide are made for each tree. The niche will accumulate water and the tree is planted at the bottom of the niche. Again, riplines should precede pitting.

Furrow-lining

Non-wetting soils can be a problem for tree establishment. The non-wetting soil must be removed by furrow-lining. A rip-line is made, as close as



A mounding plough in action.



Water-Harvesting

possible to 1 m deep. A furrow is then made with opposing discs or a blade. The furrow may need to be as much as 30 cm deep and 1 m wide at the top.

The furrows should preferably be at right angles to the damaging winds. If this is not possible the furrows should be broken at intervals and a barrier of lupins or other crop planted to alleviate erosion problems.

Inter furrow planting of crops will also help to protect against erosion.

Chemical weed control

The herbicide rates recommended below are applicable to most areas, however, care should be taken on sandy soils in low rainfall areas where problems with burning can arise. Herbicides should be applied four weeks before planting.

Dry soils (mid-slope to ridge top)

Pre-planting spray of amitrole (0.5 to 1.0 kg/ha active ingredient) mixed with atrazine (2.5 kg/ha active ingredient). Output should be between 150 and 250 L/ha, applied in a swath 1.5 m wide. The lower rate of amitrole should be used when weeds are below 5 cm in height and the higher rate when weeds are above 15 cm in height.

Moist sites (lower slopes and river flats)

Apply the same treatment except lift the rate of atrazine to 3.5 kg/ha active ingredient. Note: the swath width should be extended to 2 m where tall weeds occur, e.g. wild radish.

Control of perennial weeds (all sites)

Pre-plant spray of a mixture of Roundup® (use label recommendation for specific weed species) and atrazine (3.5 kg/ha active ingredient). Add ammonium sulphate to the atrazine at 2 per cent weight/volume adding the Roundup® subsequently to this mixture. Output should be below 100 L/ha and swath width as prescribed earlier.

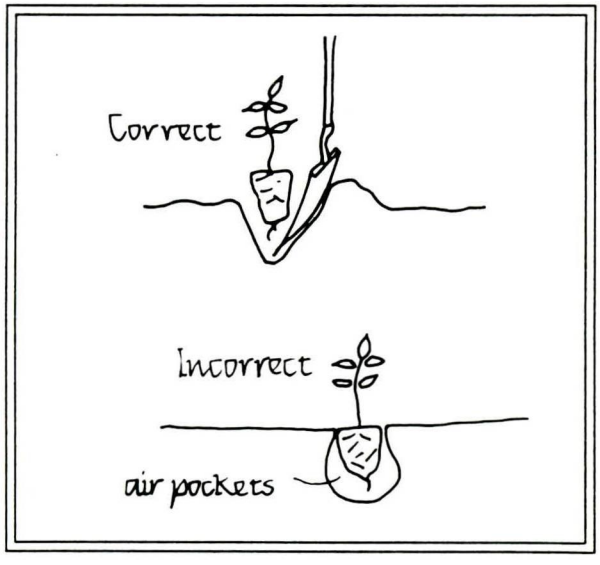
Handling seedlings

Open-rooted trees are those lifted from nursery beds without soil around the roots. Handling of these plants is critical since the roots can readily dry and the seedlings die. The handling procedure is the same for all species.

Open-rooted plants are machine lifted in the nurseries and immediately packed in wet bags before the roots can dry. They are then watered before being picked up or consigned.

Plants should be transported either in covered vehicles or else the bags and plants wrapped in plastic to protect against the wind.

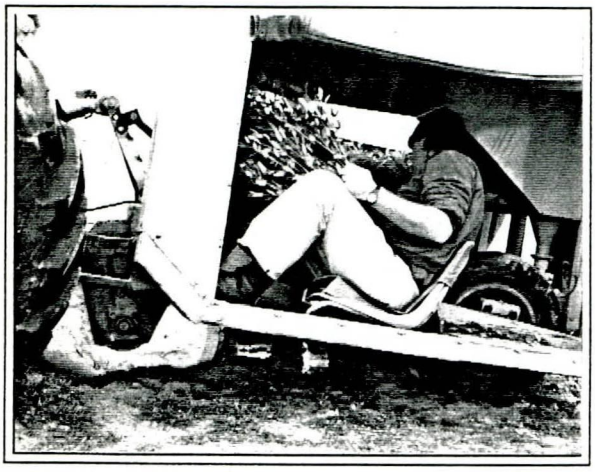
On arrival bundles of seedlings should be placed in a shady position out of the wind and well watered. Excess water from this should seep out through the bagging. Trees in pots should be straightened in the tray, placed in a sheltered position and thoroughly watered.



Avoid bell-shaped holes when planting.

Seedlings should be planted as soon as possible. If open-rooted seedlings have to be held for longer than two or three days the bags can be dug into the

ground to protect the roots from drying in the wind and watered regularly. It is preferable, however, to heel the seedlings in a sandy protected site near a watering point.



A mechanical planter.

Heeling in

Open a trench at an angle of about 45° in a weed-free area. Place the seedling trees three or four thick along the trench and refill the trench. Water heavily with a hose to force soil around the roots and eliminate air pockets. Continue to water regularly. Plants can be held like this for lengthy periods.

Planting

Timing

Planting time will differ between areas, but it should be finished by the middle of July unless the area is very wet. In areas of reliable winter rains begin planting once initial rains have penetrated the soil profile and follow up rains can be reasonably assured. This gives the plant time to establish itself before the end of the winter rains.

In drought areas, where rainfall is unpredictable, plant in the cooler months. The soil will need a good watering before planting and subsequent waterings until reasonable rainfall is received or the trees have established.

In drought areas where watering has to be maintained for some time it is particularly important that planting programmes are manageable.

Planting techniques

Potted stock:

- Dig a hole in the prepared moist ground sufficient to accommodate the teased root system.
- Tap the plant out of the pot.
- Gently tease out the roots from the side and base. If the tap root springs back into a coil, remove it with secateurs.
- Put the plant in the centre of the hole at a depth of 1 to 2 cm deeper than it was in the container. Be careful not to turn the roots upwards or allow them to coil.
- Fill the hole gently and firm with your feet.
- Build a 'saucer' around the plant using soil away from the tree.

Hand planting jiffy pots:

- Completely saturate the plant before planting.
- Remove the peat at the base of the pot and tease out the roots from the bottom 1 cm of soil.
- Then plant as for potted stock taking care to keep the peat rim below the surface soil level, otherwise it will act as a wick and dry the pot and soil.

Machine planting potted and jiffy pot stock:

Planting manually.

Mechanical planters are generally used for large scale plantings. A variety of machines are available for sale or hire.

When planting ensure that:

- Weed control and soil preparation has been properly completed.
- Non-wetting soils have been removed.
- The trees are planted in moist soil.

- The trees are planted with their roots vertically downwards.
- The firming wheels are working efficiently.

Hand planting open-rooted stock:

- Provided the soil is wet the trees should be planted early in the season (June).
- Plant 6 to 8 cm deeper than nursery level.
- Planting after the end of July is not advisable.
- Furrow-lining (see earlier section) must be done if non-wetting soils are a problem.
- Never allow the roots to dry out during planting. (Do not carry a handful of plants with roots exposed.)
- If the tap roots are excessively long and bend up in the hole the excess should be cut off.

Machine planting open-rooted stock:

The same points apply as for machine planting jiffy pots by machine. You must ensure the roots are vertical after planting.

Tamarisk cuttings

Tamarisk trees are ideally suited for windbreaks, particularly in the sandy soils around Geraldton. These trees can be started cheaply by the direct planting of cuttings.

First, create a weed-free strip 2 m wide by blading off the top 5 cm or by the use of Roundup® or other non-residual spray. Cuttings are then prepared from the current season's vigorous growth. The thickness of the cutting is not crucial, but a range of 10 to 20 mm at the thickest end is ideal. Cut 45 cm lengths, using sharp secateurs, or saws for the thickest cuttings. They can be treated with a root-inducing hormone but this is not essential.

The tractor then proceeds along the prepared line pulling a ripper penetrating to approximately 37 cm. The planter walks behind the tractor pushing three cuttings (5 cm apart) the full depth of the ripline every 5 m along the ripline. At the end of the line the tractor runs back along the line, with the back wheel 17 cm from the cuttings, firming the ground. The same procedure is used on the opposite side of the planted line.

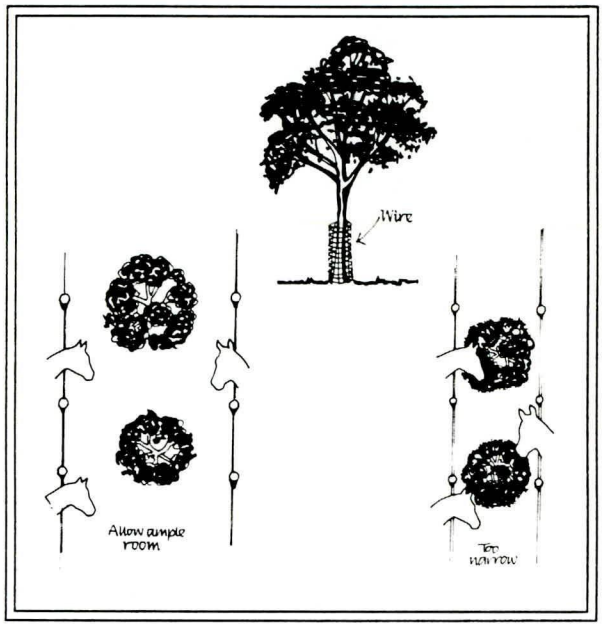
The cuttings should be planted in June, and not later than the middle of July.

Weeds should be kept away from the cuttings during the first summer, and if the summer is dry monthly watering will be necessary until the winter rains begin.

Maintenance after planting

Fences or guards are essential to protect the young trees from stock. Rabbits must also be controlled.

One useful technique is to plant along an existing fenceline then build another fence so that the trees are in a fenced laneway.



Protect trees from livestock.

The ease of erection and low material costs make electric fencing a sensible alternative. Where electric fencing is already being used, the additional fences can easily be added. If it is being used for the first time, careful planning is needed. (See Western Australian Department of Agriculture Bulletin 4131 - 'Electric fencing')

If grasshoppers are a problem follow the control measures outlined in the Department of Agriculture's Farmnote No. 47/86 'Wingless grasshoppers and their control' (Agdex 622).

Weed control

Providing initial weed control is effective into the first summer after planting and trees are growing, no follow-up weed control is necessary.

If weed control is not adequate into the first summer, however, additional spraying will be necessary. There are three options:

1. Pines (not eucalypts) can be resprayed over the trees with amitrole and atrazine (not Roundup®) at the rates prescribed earlier in the section on chemical weed control. Some spray damage may result once the trees begin to actively grow (spring) so spray as soon as the problem shows itself in late winter.
2. Two herbicides, Fusilade® and Sertin® can be sprayed directly over newly planted trees and are useful for eradicating most grasses, but will not control broad-leaved weeds. If these herbicides are used where broad-leaved weeds are also present the latter will proliferate and fill the openings left by grasses, causing further problems.
3. Systemic sprays such as Roundup® present no problems providing the trees are covered. The plants can be protected by using short lengths of 100 mm diameter plastic piping with the top covered with a small plastic bag. Place these over a number of trees, spray, and then move the covers to another set of trees. Alternatively, use a protective guard (such as an empty icecream container) over the spray nozzle to contain the spray.

(See also chapter 'Weed control near trees' page 35)

Fertilizing

The addition of a fertilizer two weeks after planting promotes faster growth and increases the drought resistance of a tree. All fertilizers, in particular nitrogen-based fertilizers, can be damaging to plants and must be applied according to instructions, either on the container or as outlined below. At the time of planting slow-release fertilizers, such as Agriform tablets and Osmocote, can be used to advantage because the chances of damage to the plant are minimal. Commercial fertilizers can be compressed and made into slow-release tablets at a low cost. The tablets can be made any size, and the recommended application of one handful is equivalent to 60 g.

Potato manure E is suitable and is not damaging to the plant if applied at the rate of one handful per tree, scattered around the base or else placed in a hole, on the downward slope, 15 cm from the trunk of the tree and at a similar depth in the soil.

Agras No. 1 or No. 2 at a similar rate and speared into the soil as just mentioned, is used by the Department of CALM for eucalypt tree establishment.

Pine trees require only superphosphate which is applied at a similar rate and manner to other fertilizers. Where the soils are known to be deficient in copper and zinc, a super copper zinc mixture is used.

Repeat fertilizer applications the following year will further increase the health and growth of the trees.

Watering

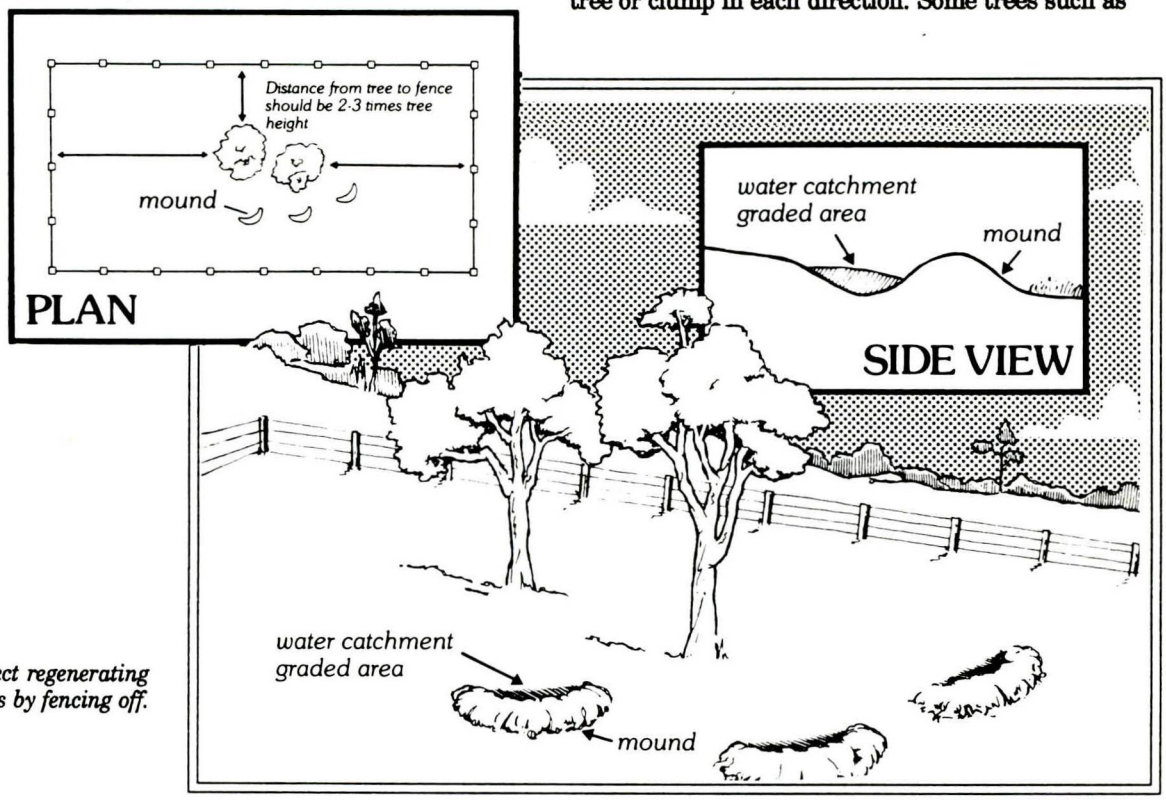
It is difficult to specify the watering needs of a plant since factors such as rainfall (timing and quantity), soil type, temperature, drying winds, plant size and water quality will control the need or frequency of watering. During years of normal rainfall, in moisture retentive soils, and where the rainfall is about 500 mm, trees can be established under natural rainfall conditions providing soil preparation and weed control have been effectively carried out.

In poor sandy soils of the same rainfall, and in all soil types of lower rainfall, watering during the first summer may be necessary. This is impossible with large scale planting, and in these situations farmers must be prepared to accept a high proportion of losses rather than the work involved in extensive watering programmes. In dry areas, supplementary watering during the first summer will ensure a higher success rate and faster initial growth.

As a general guide, water should be applied in heavy, widely spaced applications rather than light, frequent ones, which tend to create a surface root system. Where the salinity level of the water is relatively high, the accumulation of salts in the upper soil profile can be avoided by infrequent, but deeply penetrating waterings.

Natural regeneration of bush areas

Since European settlement, large areas of native bush have been cleared for townsites, farms, roads and communications. Native trees that remain in and near these disturbed areas are not regenerating, and their population is being further affected by old age, drought, strong winds, road-widening and other factors.



Protect regenerating areas by fencing off.

This large scale loss of trees is removing protection to the valuable topsoil, reducing wildlife habitats, and ruining the beauty of the area. To arrest this problem it is essential to protect and manage the areas of woodland which have been retained on farms, along road verges, and as reserves in townsites, so that they will regenerate and thus continue to survive.

Natural regeneration is a cheap way of replacing large areas of degraded bush, and requires minimal effort if the techniques suggested here are followed.

Fencing

Regeneration of some eucalypt species in assured rainfall areas, can be achieved simply by fencing an area around the tree or clump of trees to exclude domestic stock and by ensuring there are no rabbits in the vicinity.

Regeneration may occur from seed on the ground, but it is advisable to have a ripe crop of fruit on the tree at time of fencing. The fence should extend two to three tree heights from the base of the tree or clump in each direction. Some trees such as *Eucalyptus calophylla* (marri), *E. rudis* (flooded gum) and *E. loxophleba* (York gum) can regenerate readily with this limited preparation.

However, most species do not necessarily regenerate after simply fencing off an area; additional preparation is often required.

Weed control

On established farmland, slow-growing native species cannot compete against the introduced pasture grasses. The removal of weed competition is most important for the regeneration of native vegetation. However, it can be very difficult to achieve without detrimentally affecting the native seedlings as well. To achieve successful regeneration weed control must be assured well into the first summer

after germination of native species. This can be done with cultivation, herbicides, grading or combinations of the first two.

Cultivation

Cultivation for weed control must be done when weeds are actively growing. At this time seed has already dropped from the ripe fruit on the trees and cultivation will bury the majority of seed too deep for germination. Unburied seed will grow vigorously, but results are unpredictable.

The best technique is to cultivate for weed control one winter, and allow the ground to lie fallow during the following summer months. Weed germination will be reduced the following winter. If fallowing is timed to coincide with a ripened fruit crop, and good weed control achieved, regeneration of native vegetation should follow.

Herbicides

Weed control can also be improved by spray topping pasture weeds the spring before the summer/ autumn seedfall with contact herbicides such as paraquat/diquat (Spray.Seed®) or glyphosate (Roundup®) to reduce the seed bank.

Contact sprays early in autumn (particularly paraquat/diquat) will often allow tree seed to germinate. Selective herbicides may be needed later in the season.

The use of residual herbicides amongst existing native vegetation is not recommended.

For other herbicide techniques, contact the Department of CALM.

Chemical weed control has its limitations in areas of high rainfall and old pasture areas where the weeds are aggressive and the weed seed bank is strong. The following techniques will ensure more reliable results for a wider range of species and conditions.

Graded surface

The most successful way to remove weed competition is to grade 5 to 7 cm strips of topsoil to one side along the contour after the weeds have shed their seed (December-January). Seed from the surrounding trees and shrubs will drop onto the bare ground during late summer and autumn and will germinate without weed competition after the winter rains. For best results rip the graded strips at 1 m widths to give germinating seedlings a better chance to develop strong taproots. If this cannot be done without damage to parent trees the graded surface should be tine cultivated. This technique can not be used if removal of the top 5 to 7 cm of soil exposes a clay sub-soil. Establishment of seedlings on clay is known to be poor.

Water harvesting

Water harvesting is used to increase the amount of available water to germinating plants as well as to provide a collection point for seed that would normally be washed away. It can be a valuable addition to all methods of regeneration described in this chapter.

Water is harvested by building small crescent-shaped banks across the flow of surface water; that is, on the contour. They should be short - say 10 m - to avoid excessive overflows that may cause erosion. They can be constructed by using a backblade or roadgrader to bare strips 1 m or more wide. Move the top-soil down hill to form a curved bank that will hold water. In heavier soils the bare area should be ripped with a chisel plough to improve water penetration.

Water harvesting is especially valuable in the drier zones of the wheatbelt, and on erodible slopes.

Burning

The yearly burning of natural areas of bush is detrimental to the stands. Burning of a weed-infested stand of natural bush area will only promote a better weed crop, which will compete with, and kill, any germinating native seedlings, unless the fire is hot enough to partially sterilize the soil and kill any weed seed present.

To achieve a relatively high intensity fire, old stag trees and dead timber are removed to create openings in the stand. This material is heaped over an area in sufficient quantity to ensure a fire hot enough to kill weed seed in the top 5 to 7 cm of soil. The area of the fire-heap will depend on the size of the openings and available fuel. Fire-heaps can be in windrows or in clearings with a diameter of 5 m or more. The height of the fire-heap is the important factor, and should be no lower than 1 m of reasonably compressed fuel. The stacks of fuel need to be far enough away from the trees to prevent damage, and

should be fired in late summer or early autumn. The seed capsules of banksias, hakeas, and eucalypts are all triggered by fire.

If trees close to the fire-heap have a good crop of ripe fruit the heat of the fire will dry out the capsule valves, causing the fruits to open and release seed a day or so later. The cool ashes left by the fire form a fertile seedbed for the regenerating bush.

After burning, it is wise to augment the supply of eucalypt seed by removing branches carrying ripe fruit from nearby trees and laying the branches on the cooled ash-bed. The branches should be widely distributed over the ash-bed, making sure the edges, where the most successful germination will occur, are well covered. The fruit will open and deposit the seed before the winter rains. In windy situations use a heavy branch to anchor the smaller seed branches.

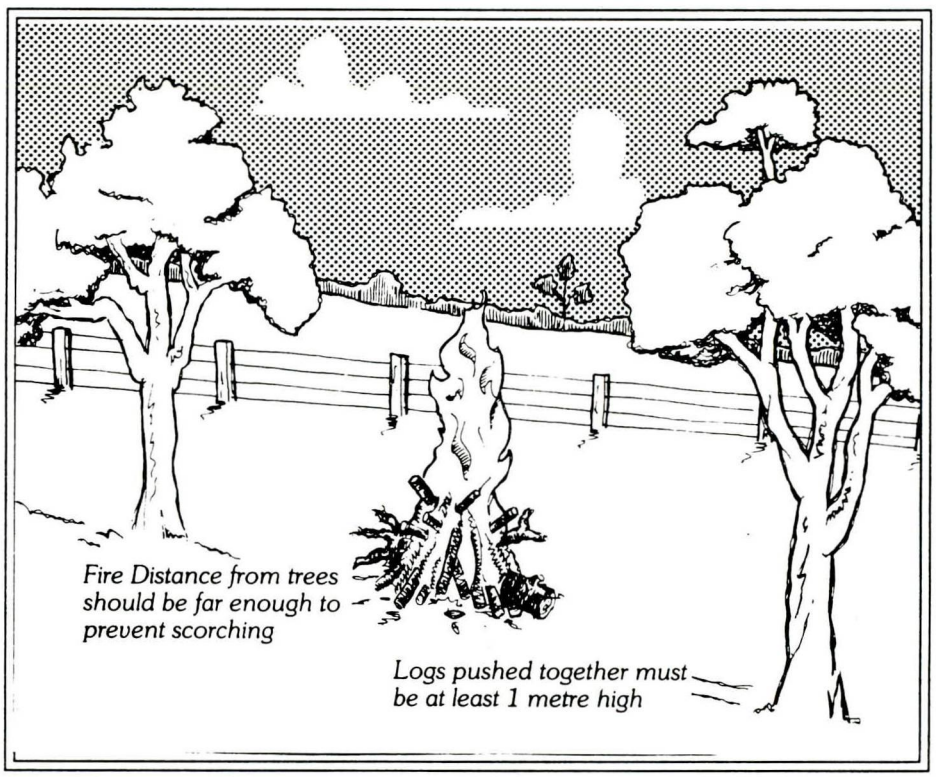
Eucalypt fruit is ready for harvesting when the capsules turn reddish-brown or grey and the valves turn brown. Most eucalypts carry a series of crops in various stages of development. Branches with older more mature fruit with the valves unopened should be chosen.

If seed is not available locally it can be purchased from seed merchants, and broadcast by hand over the ash-beds. The seed can be mixed with weed-free sand to assist broadcasting. In exposed situations, place branches at random around the broadcast seed to prevent the seed blowing away.

Rainfall is the most important factor for successful regeneration from seed. In rural areas which have periodic droughts it is advisable to regenerate natural bush stands in sections over a period of years to ensure success.

Summary

- The area must be fenced to keep stock out.
- Rabbits, if present, must be controlled.
- The trees should be checked for ripe fruit. If ripe fruit is not present in the stand then it will need to come from an outside source - other trees, branches, or picked fruit; or from a reliable seed merchant.
- Weed competition must be eliminated.
- Water harvesting and high intensity burning will increase the chance of successful regeneration.



High intensity fires will kill weeds, form a seed bed and trigger seed release.

(Diagrams courtesy of Department of Conservation and Land Management)

Remnant vegetation protection scheme

Background

Remnant vegetation on private land is an important natural resource contributing to flora and fauna conservation, soil conservation, aesthetics and amenity. Recognizing the broad benefits to the community of such remnants, the State Government has implemented a scheme to assist private land users to voluntarily protect and manage areas of native vegetation on farms. The scheme provides technical advice to farmers and a subsidy for the protective fencing of such areas.

Elements of the scheme

Farmers can nominate areas of native vegetation that they wish to protect to their local Land Conservation District Committee. Where a Land Conservation District does not exist, farmers will need to nominate areas initially to the local Department of Agriculture Office.

The Department of Conservation and Land Management have developed criteria which Land Conservation Districts can use to put in priority the nominations within their areas.

The Government contributes 50 per cent of the cost of fencing; it is allocated on the basis of priority. The subsidy provided depends on the type of fence erected. The maximum subsidy is $1,150 per km.

Funds will be allocated through the Land Conservation District Committee or Department of Agriculture office to the nominated land owner who will enter into an agreement to manage the area as native vegetation for 30 years. The area will be protected by a special notice under the Soil and Land Conservation Act and details will be registered as a memorial on title.

Conditions

1. Areas of remnant vegetation considered under this scheme should be in good condition or be able to be regenerated to good condition.
2. Land entered into this scheme will not be able to be grazed by livestock or managed in any other way that would degrade the conservation values of the vegetation.
3. The land owner will remain responsible for the management of the area. Officers of the Department of Agriculture and CALM will be available to provide advice on management where required.
4. Land Conservation District Committees will be requested to report on the condition of the vegetation from time to time.

Windbreaks

Introduction

Tree windbreaks can reduce the speed and damaging effects of wind. They are capable of providing substantial benefits when correctly designed and located.

Benefits recorded from users of windbreaks in Western Australia include:

- protection from sand blasting and soil erosion;
- 'silt traps' to catch windblown sand;
- a reduction in chilling deaths of newborn lambs;
- increases in crop and pasture production.

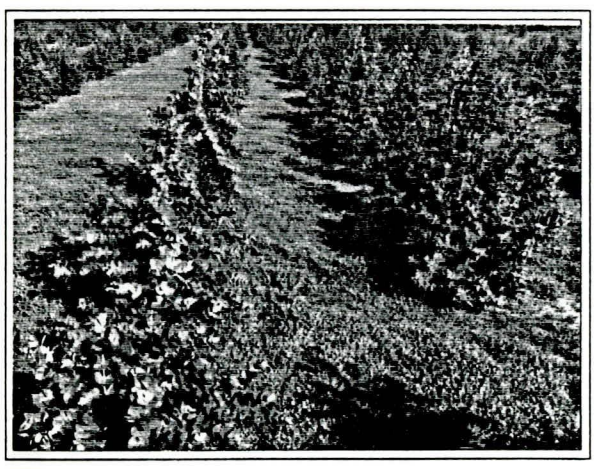
Evidence from eastern Australia indicates that windbreaks can also provide:

- increases in animal production (particularly sheep);
- a reduction in chilling deaths of newly-shorn sheep.

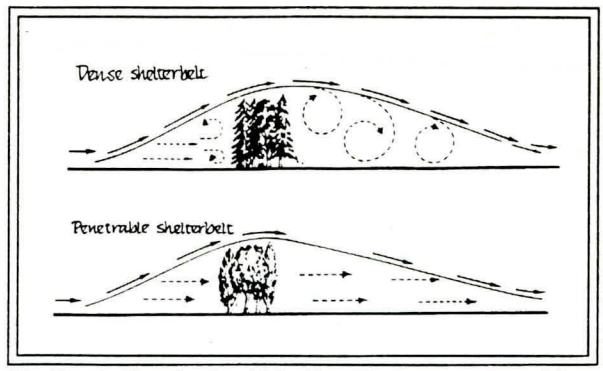
In areas prone to soil erosion, windbreaks should be used in conjunction with conservation farming practices, such as, stubble mulching, direct drilling, avoidance of over-grazing, and maintenance of a rough soil surface when cultivating.

Windbreaks are a long-term project. Some years will elapse before the trees reach a height where they will provide substantial shelter. However, once at this height, they will last many years.

Specialist advice on tree species selection and whole-farm planning should be sought before starting extensive planting programmes.



Testing species for use in windbreaks.



Ideally windbreaks should be 35 to 45 per cent permeable to the wind.

The protection given by windbreaks

The effect of a windbreak depends on its height. The distance over which it affords protection is expressed in multiples of its height; usually 20 times the height of the windbreak.

Designing windbreaks

Design principles

For maximum distance of protection the windbreak must be permeable to wind. Trees with very dense foliage form poor windbreaks. Trees that provide a barrier that is 35 per cent to 45 per cent permeable to the wind, are the most effective.

Foliage must extend to ground level or strong winds will funnel under the windbreak and increase the wind speed.

The windbreak need only be narrow, forming a rather abrupt obstruction to the wind. The zone of protection may be greatly reduced if the belt of trees is too broad, when it tends to act like a solid barrier creating eddying winds of high velocity.

Alignment

Ideally the tree belt should be at right angles to the direction of the most damaging wind. For example, to give protection from a northerly or southerly wind requires a break to be aligned east to west. However, the alignment of the break may vary up to 45 degrees either side of a right angle to the wind with no loss in effectiveness, provided the break is long enough.

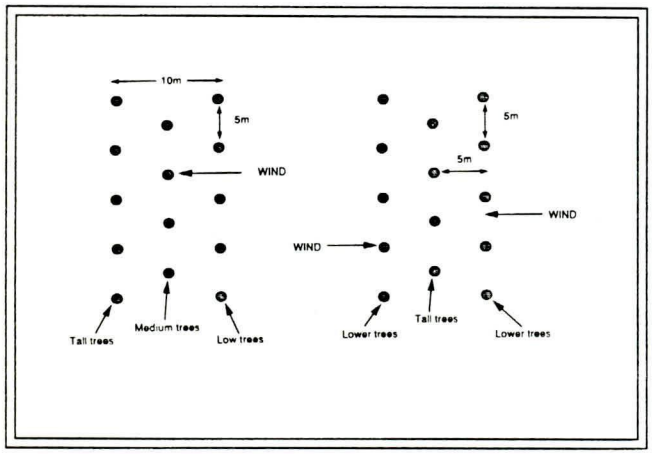
The shading of adjacent crop or pasture by the belt of trees also needs to be considered. Shading is minimized by aligning breaks north-south.

Length

A minimum length of 20 times the height of the trees is recommended. This should be increased to at least 30 times the height for breaks that are not at right angles to the damaging wind. This minimizes the effect of eddying around the ends of the windbreak.

Planting pattern

The simplest form of windbreak is a single row of trees of a type that retain their foliage to ground level. Tamarisk and some species of pine fulfil this requirement. However, because of the risk of losing some trees and a gap forming in the break, a minimum of two or three rows of trees is recommended.



An effective windbreak.

Most of our taller eucalypts shed their lower branches leaving a bare trunk. If you use this type of tree in your windbreak, it is essential to plant a second row of shorter trees. The species selected for the second row must retain its foliage to ground level. Again, to avoid gaps caused by the loss of trees, two rows of each of the two types of trees should be established.

Gaps and the ends of windbreaks

Windspeeds are higher than normal through gaps, and round the ends of the windbreak. Gaps should be avoided. If access is needed through a windbreak, form the track diagonally through the break. An alternative solution is to locate access through the windbreak on an area of soil that is not liable to erode. Similarly, the end of the windbreak should be located where there is minimal risk of soil erosion.

Ends of windbreaks

The ends can join onto other tree lines or natural vegetation. If they finish in an open area, the trees should be thinned out towards the end, or shorter and shorter trees used to taper the windbreak down.

Distance between windbreaks

In planting a series of parallel breaks to protect a large area of land from the wind, the distance between each break will depend on the height of the trees and the windspeeds you need to combat.

For maximum benefit, windbreaks should be no further apart than 10 to 12 times their height, but such close spacings are likely to be uneconomic except for the protection of high-value horticultural crops.

A more realistic spacing for the broadscale farmer is 20 to 30 times their height. Even those spacings may be extended if a mild level of soil erosion is acceptable, and if the windbreak system is accompanied by conservation farming practices.

Some indication of the downwind distance of protection can be gauged from remnants of native vegetation remaining in or on the borders of paddocks subject to wind erosion. If the height of the vegetation

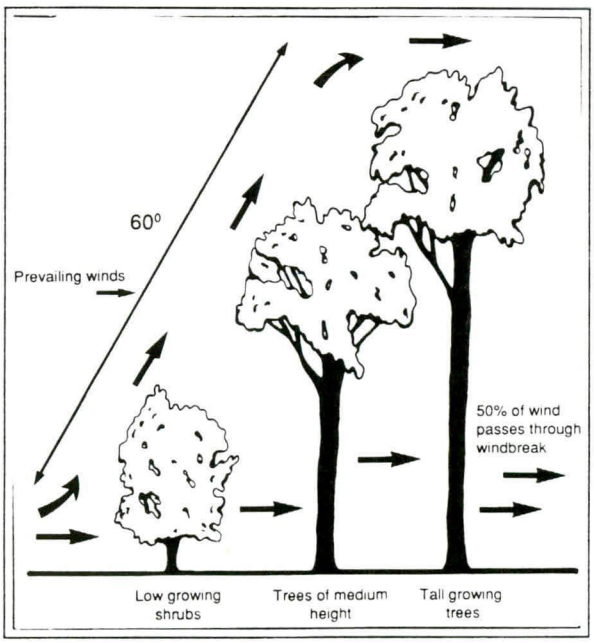
Windbreaks can provide fencing materials and commercial timber

is measured, and also the depth of the protected (non-eroded) area downwind of it, the spacing needed between windbreaks can be calculated.

The location of windbreaks in hilly country

Extra care is needed in siting windbreaks in hilly country. Some broad principles that need to be followed are:

- they follow the contour on hill slopes;
- they cross the contour in valleys;
- they need to be spaced more closely on the windward side of the hill and on the upper leeward side of the hill.



Foliage must extend to ground level. This can be achieved with a combination of trees and shrubs.

Establishing windbreaks

Belts of trees for breaks can be established by planting seedlings, or by direct drilling.

Recommended spacings for planted seedlings are 4 m between trees and between rows in areas with average annual rainfall exceeding 500 mm. For areas of less than 500 mm average rainfall, the spacing should be extended to 5 m.

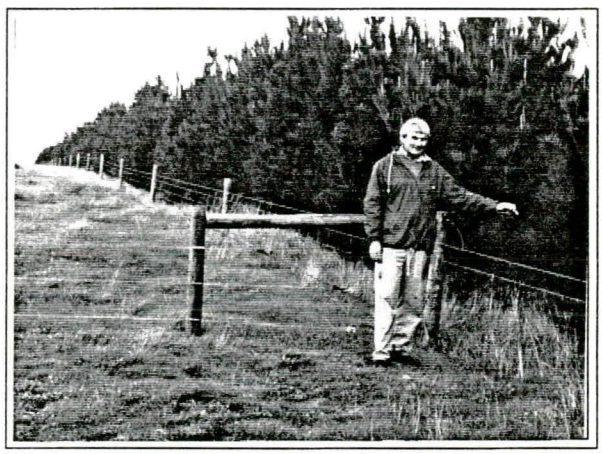
Direct drilled belts should be thinned to roughly these spacings.

Fencing

If you carry stock, windbreaks should be permanently fenced. Stock will otherwise browse the lower branches and destroy the important shelter near ground level.

Maintaining windbreaks

Tree windbreaks require little maintenance once they are established.



Windbreaks must be fenced to protect them from livestock.

Weeds

Weeds in fenced-off windbreaks may pose a fire hazard, particularly when the trees are young. Provided the trees have reached a height of 1.5 to 2 m, weeds can be controlled by 'crash' grazing with sheep. Care must be taken to remove the sheep as soon as they start to browse the trees.

Some recommended species for windbreaks

Note:

- Figures in brackets are the likely heights of the mature trees in metres.
- Species recommended for a particular rainfall zone can also be used in an area with a higher rainfall, but not the reverse.

Trees that retain their foliage to ground level

Light soils - 400 to 500 mm rainfall

Eucalyptus cladocalyx var *nana*	-	dwarf sugar gum (8)
E. platypus var *heterophylla*	-	coastal moort (7)
Pinus canariensis	-	canary pine (12)
P. halepensis	-	Aleppo pine (12)
Tamarix aphylla	-	tamarisk (10)

500 to 600 mm rainfall

Casuarina obesa	-	swamp oak (10)
Eucalyptus conferruminata	-	Bald Island Marlock (10)
E. todtiana	-	coastal blackbutt (6)
Melaleuca lanceolata	-	Rottnest ti-tree (6)
Pinus pinaster	-	maritime pine (12)
Tamarix aphylla	-	tamarisk (10+)

More than 600 mm rainfall

Agonis flexuosa	-	peppermint (10)
Eucalyptus cinerea	-	mealy stringybark (12)
Melaleuca nesophila	-	western tea myrtle (5)
Pinus pinaster	-	maritime pine (17)
P. radiata	-	Monterey pine (20+) only on yellow sand

Heavy soils 400 to 500 mm rainfall

Casuarina obesa	-	swamp oak (10)
Eucalyptus gardneri	-	blue mallet (10)
E. platypus	-	moort (6+)
E. spathulata	-	swamp mallet (6+)

More than 500 mm rainfall

Agonis flexuosa	-	peppermint (10) above

600 mm rainfall only

Casuarina obesa	-	swamp oak (10)
Pinus radiata	-	Monterey pine (20+)
Lephostemon confertus	-	Queensland box (10) above 600 mm rainfall only

Trees that shed their lower branches

Light soils 400 to 500 mm rainfall

Eucalyptus camaldulensis	-	river red gum (15) but only in drainage lines where extra moisture is available

E. cladocalyx - sugar gum (18)

More than 600 mm rainfall

Eucalyptus botryoides - southern mahogany (20)
E. gomphocephala - tuart (25)
E. maculata - spotted gum (25) on yellow sands only

Heavy soils 400 to 500 mm rainfall

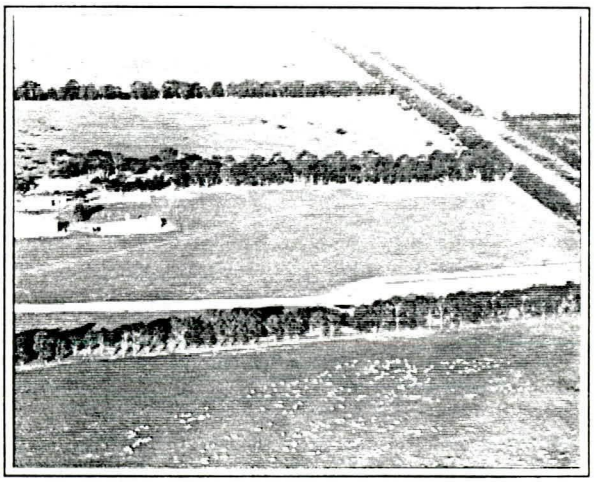
Eucalyptus kondininensis - Kondinin blackbutt (12)

500 to 600 mm rainfall

Eucalyptus crebra - narrow-leaved red ironbark (16)
E. melliodora - yellow box (20)

More than 600 mm rainfall

Eucalyptus diversicolor - karri (40)
E. globulus - Tasmanian blue gum (30)
E. maculata - spotted gum (25)
E. muellerana - yellow stringybark (30)
E. nicholii - Nichol's gum (20)



Windbreaks on the Esperance plain.

The robbing of crops and pasture

The effect of tree roots robbing water and nutrients far into adjacent crop or pasture can be reduced by root pruning (ripping) along the edges of the windbreak. If this practice is to be followed, ripping should start when the trees are no more than five years old, and be repeated every few years.

New-land development

Farmers developing new land could leave strips of native vegetation to act as windbreaks. This is a cheaper alternative than planting or drilling trees. However, if the strips are to be effective, they must be tall enough to provide shelter, and they will need fencing to exclude stock.

Should you plant windbreaks?

Broadscale farmers may consider the cost of total farm protection by windbreaks to be too high, or uneconomic due to the productive land taken up by the trees.

If this is your situation, you might consider using them to protect special areas on the farm:

- areas especially prone to erosion;
- lambing paddocks;
- to protect holding yards;
- to protect dams and roads from filling with windblown sand.

Farmers in areas of more than 750 mm average rainfall have the option of combining timber production with shelter from the trees in windbreaks. Special techniques are required to manage breaks for this purpose. These can be explained to you by Advisory Officers of the Department of Conservation and Land Management.

Weed control near trees

Effective weed control is essential if trees are to be successfully established on farms. Weeds compete with young trees for light, nutrients and moisture. Young trees growing in a weed free environment will not only have a better chance of survival, but will also have a better growth rate.

There are a wide range of herbicides which control a variety of weeds. Herbicides can be divided into three major groups.

Knockdown herbicides

These herbicides are absorbed by the plant leaf - they control weeds which are present at the time of spraying. Common knockdown herbicides include Roundup®, Gramoxone® and Tryquat®. These herbicides become inactive after contact with the soil and are not residual. Wetting agents should be added to facilitate even coverage. Care should always be taken if spraying near existing trees - avoid spray drift damage.

Residual herbicides

These herbicides are applied to the soil and are absorbed by plant roots. They slowly kill existing weeds and also prevent further germinations. Atrazine and simazine are common residual herbicides.

Combinations of residual and knockdown herbicides

These herbicides quickly kill existing weeds and also prevent further germinations (e.g. amitrole and atrazine).

The most effective chemicals for weed control prior to tree planting are a combination of a knockdown and a residual herbicide. When used at the recommended rate, they give reasonable weed control for 12 months, you should spray at least two weeks prior to planting.

Although a knockdown + residual chemical mix is the preferred option, some people may choose to use a knockdown herbicide. To get the best results (in the case of annual weeds), spray the site about two weeks after the opening rains and then again about a week before planting the trees in June or July. This is even more important in high rainfall areas. If only spraying once, spray one to two weeks before planting.

Selective and post plant sprays

Some selective grass herbicides are available which can be sprayed over established trees. Products tested include Fusilade® and Sertin®. Simazine has also been used over eucalypts to provide additional residual control of emerging seedlings.

Hints

1. For single rows of trees, spray a strip about 1.5 m wide.
2. When using Vorox® or simazine/Roundup® mixtures through a boom spray, apply a minimum of 200 L/ha of water.
3. When using a Roundup®/simazine mixture, half fill the tank with water, add the simazine, mix thoroughly, add the Roundup®, then the balance of water. Use the mixture promptly.
4. Simazine is sold under the trade names of Farmco Flowable Simazin-500® and Flowable Gesatop 500 FW®.
5. *Micro Herbi.* Use the nozzle as prescribed in the table overleaf and walk at 1 m/second (a slow walk). It will spray a strip about 1.2 to 1.5 m wide.
6. *Knapsacks.* These recommendations are based on applying water at the rate of 15 L (usually one tank full) on a strip 100 m long and 1.5 m wide (150 m^2). Before applying the herbicide, do a dummy run on a similar area somewhere else, with just water, to calibrate your speed of operation. As a general rule, thoroughly wet all plant foliage.
7. In all cases, use the higher recommended rate for large weeds and the lower recommended rate for small weeds. Best results for weed control are usually achieved when weeds are young and actively growing. Observe the manufacturer's recommendations along with all necessary safety precautions.

Masks and protective clothing are essential, particularly when using knapsacks and other operator carried sprayers.

Chemical control

	Application rate		
	Boom spray L/ha	Knapsack mL/L water	Micro herbi mL herbicide/ mL water
Annual weeds (capeweed, ryegrass, bromegrass)			
Knockdown			
Tryquat*	4.5	7.5	
Gramoxone*	3.0	5.0	
Roundup*	1-3	1-3	1:3 (blue nozzle)
Knockdown + residual			
Flowable Vorox AA			
Low rainfall (<600 mm)	3-4	3-4	
High rainfall (>600 mm)	5-6	5-6	
Simazine (50%)	10-16 (higher rate in wet conditions)		
Perennial grass (kikuyu, couch)			
Fusilade*	4.0	5.5	
Roundup**	6-9	6-9	2:1 (yellow nozzle)
Perennial broadleaf			
Roundup**	6-9	6-9	2:1 (yellow nozzle)
Selective post planting			
Eucalypts			
Fusilade			
Sertin			
Simazine			
Pines			
Fusilade			
Sertin			
Amitrole/atrizine			

* Add simazine to obtain residual activity.
** Roundup® is systemic in action and can kill trees if spray drifts on to green material.

CAUTION: Always read the label before using chemicals. Refer to chemical companies for more detailed information and recommendations.

Fencing trees from stock

Protecting trees from livestock for the first two or three years is as important as any of the other aspects of a good tree planting programme. One or two animals can destroy many hours of work and many dollars worth of trees in less than a day.

The ease of erection and low material costs make electric fencing a sensible alternative. Where electric fencing is already being used, the additional fences can be easily added. If it is being used for the first time, careful planning is involved. Without good earthing and careful planning, electric fencing should not be considered.

Bulletin 4131, 'Electric fencing' (Agdex 723/75), published by the Western Australian Department of Agriculture, provides a comprehensive guide to the construction of this form of stock control.

Many farmers are also planting clumps of trees into their paddocks to improve the look of their farm. A lot of time and material can be used in protecting these trees. Barbed wire (not electrified) and sloping posts can save time and money as a permanent fence. Posts are driven into the ground about 30 degrees from the vertical (leaning into the trees) and spaced no more than 5 m apart. The barbed wire is pulled by hand (not strained) and tied to the post. The number of wires used depends on stock, but five wires will control sheep. The bottom wire must be close to the ground. Three wires have been used to control cows and calves.

Any fencing of trees should be considered as permanent. By putting in gates, grazing under trees can be carefully controlled.

Further reading

'Electric fencing', Bulletin 4131, Department of Agriculture, Western Australia.

Insect pests of eucalypts and other native plants

This chapter describes typical symptoms seen on trees after attack by a range of insect pests. It also provides a description of the adult insect and/or its larval stages. An excellent Bulletin, 'Insect and allied pests of extensive farming' (Bulletin 4195) is available from the Department of Agriculture. Colour photographs of all the pests described here and the damage they cause are included in that Bulletin.

Recommendations on control measures frequently change so no details are given here. For this information you should contact your nearest Department of Agriculture office or the Department of Conservation and Land Management.

Autumn gum moth

Damage

Young caterpillars of the autumn gum moth feed as a group and skeletonize the leaf so that only the veins remain. Older caterpillars feed on the whole of the leaves, and branches are completely defoliated, with only a few curled brown leaves remaining, in which the caterpillars shelter during the day.

The juvenile leaves of bluegum trees are preferred and the Tasmanian bluegum is the most commonly attacked species in Western Australia, although river red gum is also sometimes attacked.

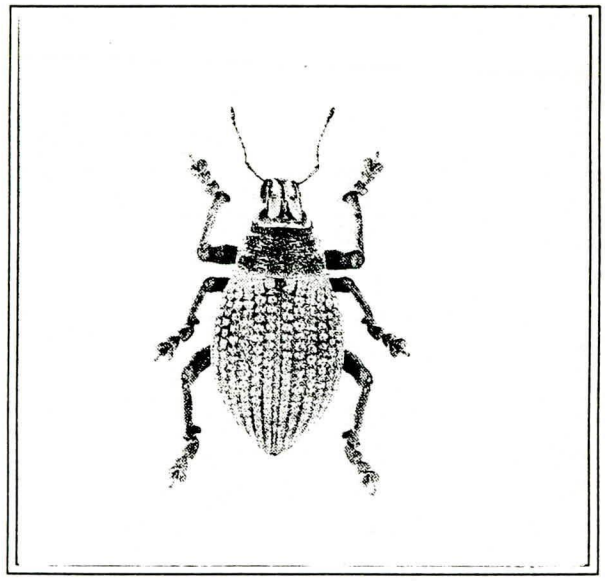
Description

Young caterpillars are light yellow-brown with dark brown and green markings. Older caterpillars are dark greenish brown, up to 30 mm long, with two red patches containing two yellow swellings on each segment, those on one segment being particularly prominent. They are not obviously hairy.

Catasarcus weevils

Damage

On farms, most damage has been noticed on Australian native plants grown around farm buildings and along farm fences as windbreaks. Generally



Catasarcus weevil

such plants are eucalypts. In the Esperance area the planted species most commonly attacked are tuarts, while around Albany, bluegums are often attacked.

The weevils chew leaves around the edges, giving a scalloped appearance. Heavy infestations can strip trees completely, especially if they are small. The seriousness of the damage is largely a matter of opinion; some farmers claim trees are severely retarded or even killed, while others find that trees can compensate for the defoliation. Young trees are most likely to be adversely affected. Some observations suggest that trees suffering from some other setback are most affected - for example, trees suffering from water stress or nutritional imbalance.

Description

These weevils are restricted to Western Australia and some parts of South Australia. At least 41 different species have been identified.The species most commonly found in the Esperance region has a black and ochre stippled abdomen; the thorax is black, while the head has two ochre coloured lines running down its 'snout'. Overall the insect is a large robust creature, about 15 mm long. When disturbed they can 'play dead', tucking their legs tightly beneath them and dropping from the leaf or branch upon which they have been feeding or resting.

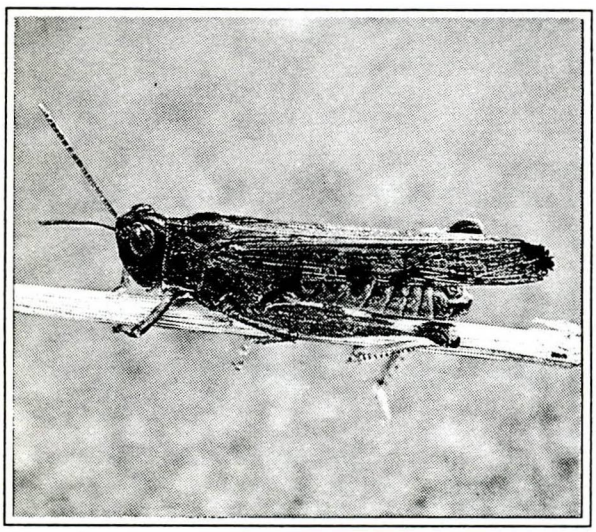
Grasshoppers

Damage

Young trees planted into paddocks, or in belts along paddock fencelines, can be seriously damaged or killed by grasshoppers. The wingless grasshopper and Australian plague locust are most likely to be the cause of damage, but other types of grasshoppers with different habits may be involved.

Wingless grasshoppers occur in a coastal belt up to 50 km wide, from Lancelin north of Perth, to east of Esperance on the south coast.

Australian plague locusts can extend into all agricultural areas, originating in inland pastoral areas, if seasonal conditions (spring and summer rain) suit them.



Plague locust

The small plague grasshopper occurs in the drier inland agricultural regions, and can build up to large numbers in some seasons.

At least 12 other types of grasshoppers occur throughout all these regions, and may be responsible for damage at times.

Gumleaf skeletonizer

Damage

The young caterpillars of gumleaf skeletonizers are gregarious and feed together on the lower leaves first. They eat most of the leaf tissue except the veins reducing the leaves to a skeleton. The older caterpillars feed separately and may leave only the midrib. Trees may be completely defoliated by heavy infestations, but death does not usually result.

Many species of eucalypt are attacked, of which jarrah, wandoo and river red gum are probably the worst affected.

Description

The caterpillars are green and yellow with long pale hairs which are irritant to human skin. A characteristic brown horn-like tuft on the head is formed from moulted head capsules stacked on top of each other. Fully grown caterpillars are about 25 mm long.

Gumtree scale

Damage

Gumtree scales infest young stems and leaves, sucking the sap and producing a sugary secretion which may cover the leaves and cause them to glisten. A sooty mould fungus often infects this secretion and causes the leaves to turn black. Ants commonly attend the scales to feed on their sugary exudate, which they promote by stroking the scales. Continued attack results in debilitation of the tree and small trees may die. A number of eucalypts are attacked by this scale, but in Western Australia wandoo is probably the most commonly infested, particularly in the wheatbelt.

Description

The female scale grows 3 to 4 mm long and is fixed to small stems, branches and near the midrib of leaves. The felted globular sac which encloses each adult varies from white or yellow to dark brown and when squashed contains a reddish fluid. The male scales are smaller, being 1 to 2 mm long, white and more elongated than the females and are often clustered above the females on the stems or leaves.

Leafblister sawfly

Damage

The larvae of leafblister sawflies mine the leaves of eucalypts and feed within the upper surface of the leaves, producing rounded blotch mines, which may cover the whole leaf surface, giving it a scorched appearance. Heaviest damage usually occurs to foliage within 6 m of the ground and young trees are

worst affected. Older flooded gums may suffer serious damage at heights exceeding 10 m. More than 15 eucalypt species, both introduced and native to Western Australia, are attacked. Of these, rose gum, swamp mahogany, river gum and flooded gum are the most heavily attacked.

Description

The adult sawflies are small orange and black active wasps, about 5 mm long. The larvae are yellow-cream with dark spots, about 5 mm long when fully grown, slender and somewhat flattened. They feed actively in the leaf.

Lerp insects

Damage

The developing nymphal stages of lerps suck the sap of the leaves while sheltering under their 'lerp' scales. In heavy infestations this eventually results in discoloration of the leaf which turns reddish brown and eventually dies and falls off. Severe defoliation may result from heavy infestations, and debilitation and death may follow repeated attacks.

Flooded gum is the main host tree in riverine and farm sites and wandoo may also be infested in drought affected wheatbelt areas. River gums planted as a saltland rehabilitation species may also be heavily infested. Remnant areas of flat topped yate in swamps in southern areas can be severely affected.

Description

The adult psyllid is about 4 mm long with transparent wings and a yellowish brown body. It is usually found in numbers on lerp infested leaves in summer. The lerp scale when fully formed in spring, is about 8 mm long, horn shaped and tapering from about 0.5 to 4 mm in width and is yellow to pale brown. Under each lerp scale there is an orange nymph which is active when the leaf is moved.

Jarrah leafminer

Damage

Jarrah leafminer larvae feed between the leaf surfaces during winter, producing blotch mines which often cover the whole leaf surface giving an appearance resembling fire scorch. Severe infestation may be found commonly along forest edges, in clearings and on partly cleared farmland. Jarrah is the main host tree, with flooded gum also heavily attacked in riverine environments and partly cleared farmland. About ten other eucalypts native to Western Australia may suffer slight damage.

Description

The adult moth is grey-brown and about 6 mm long. Maximum activity may be observed on sunny autumn days when moths run up and down twigs and leaves after emerging from the soil.

The mining larvae are cream coloured and reach 4 mm long when fully grown.

Leaf beetles

Damage

Many eucalypt species are attacked by larvae and beetles. The larvae can strip most of the leaves from young trees and seriously retard their growth. Adult beetles feed mainly on leaf edges and do not generally cause such serious damage.

Description

The larvae are generally a yellowy cream with some black patches; they grow to about 5 mm long. The adult beetles are generally brightly coloured, usually pink, orange or red-brown. They are similar in shape to ladybird beetles but are larger, being up to 10 mm long.

Spitfires

Damage

Larvae of spitfires feed on the foliage of young trees and regrowth stems, and can strip the branches of foliage particularly at the tops. This is usually replaced during the spring-summer flush of leaf growth. Serious retardation of high growth may result from repeated attack but death is unlikely. Wandoo is the most commonly attacked species in Western Australia.

Description

The larvae vary from dark blue or black to yellow and brown depending on the species and are about 25 mm long. The body is sparsely covered with white bristly hairs and the tail, which is raised when

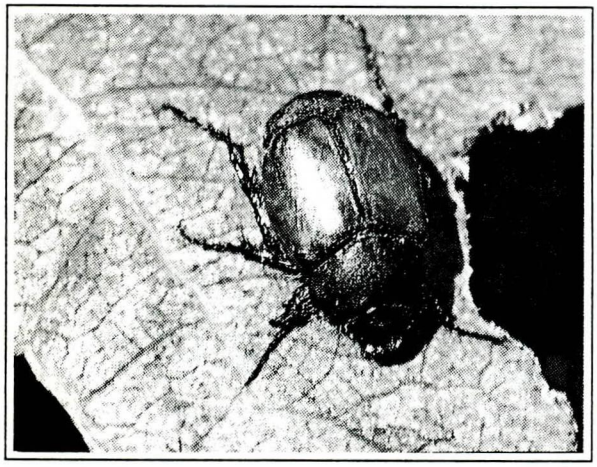
disturbed, is yellow and can exude an odourous fluid. During the day the larvae congregate in clusters of 20 or 30 for protection and disperse at night to feed.

The adult wasps are mainly black or brown, with yellowish markings and about 20 mm long.

Spring beetles

Damage

Many eucalypt species are attacked by the beetles in wheatbelt and southern areas, and serious defoliation may result. Larger trees may be pruned into rounded shapes, and smaller trees may be stripped completely of leaves. Death of young trees may occur, especially if they are droughted, or waterlogged, and cannot grow new foliage. Seedling trees in rows along paddock boundaries can be highly vulnerable, as beetles from adjacent paddocks congregate on them.



Spring beetle

Some species of spring beetles feed on flowers of many native plants, and can cause damage to blossoms wanted for the flower trade.

Description

The beetles are small scarab or cockchafer beetles, about 5 mm long. They may be bronze and brown, or orange and dark blue.

Tree lucerne (tagasaste) moth

Damage

Caterpillars of the tree lucerne moth can completely defoliate tagasaste (tree lucerne), perennial lupins, and some native leguminous shrubs such as *Hovea* spp. Leaves, twigs and smaller branches are webbed together, with caterpillars congregating in the webbing, and with dark specks of frass (caterpillar droppings) caught up in the webbing. Established shrubs are unlikely to be killed, but plants less than a year old may be at risk. This insect is not commonly reported, probably because, until recently, most tagasaste has existed as ornamental plants in farm yards. Increased farm plantings for fodder or soil conservation will provide more extensive opportunities for tree lucerne moth. Lost drymatter production may be significant, and will depend on how tagasaste is used on farms.

Description

The caterpillars have a fringe of sparse hairs, and grow to 35 mm long. The head is pale brown through to a shiny red-brown, and behind it is a black collar with three white stripes. The body is light green with a yellow and white line just above the legs on each side. Above this there is a dark band made up of black blotches on each segment. Each black blotch has long hairs arising from it, and also has one or two white spots. Three pairs of dark legs at the front are followed by four pairs of green 'sucker legs'. They are slender compared with other larvae such as budworm, which they superficially resemble.

The moth has a distinct 'beak'. At rest with wings folded it is about 20 mm long, and 35 mm across with its wings spread. The fore wings are dark grey-brown with a lighter grey patch towards the rear edge. Often there are light brown lines where the wing scales have been rubbed off. The hind wings are orange-yellow with a broad dark brown margin. The underbody is nearly white, with a white face and coiled feeding tube. Moths have been caught in light traps from early spring to late autumn.

Fitting trees into the farm plan

Trees are only one aspect of farm management, and must be integrated with a whole-farm plan to avoid long term problems. Most trees will survive for more than 30 years, and the plan they fit into also needs to be for at least that period.

Aerial photos serve as good base maps.

In many instances, windbreaks/shelterbelts can give a net financial gain from increased crop and pasture yields, and reductions in lamb and ewe deaths.

As a rough guide, most farms in southern Western Australia would benefit from having 10 to 15 per cent under managed trees.

A good base map should be used, such as an air photo, showing the main topographical features, for example ridge crests, waterways and creeks, rock outcrops and breakaways. This map should also show information on the main land classes or soil types and areas with a known or predictable soil erosion, waterlogging or salinity hazard.

Sites for planting

Often 'square paddock' farm layouts are far from the best possible and since 1955, the Soil Conservation Service of the Department of Agriculture has developed the conservation farm planning concept. This is an integrated approach to planning the farm layout.

Trees need to be located:

- to give effective stock shelter and provide protection from wind and water erosion;

A two year old tamarisk windbreak.

- where they conflict least with farm operations, and give a net gain in productivity;
- where they will grow fast into healthy long-lived trees and beautify the landscape.

Tree belts need to be fenced to avoid stock damage. Consequently, new plantings located near existing fences or proposed new fence lines will reduce fencing costs. Many fences in a conservation farm plan are located:

- between land classes, such as saltland, deep sand, heavy clay;
- alongside creeks and waterways;
- along ridge crests;
- along rocky outcrops and breakaways;
- along contour banks and along large levee, diversion and interceptor banks.

A six year old tamarisk windbreak.

In all these positions there is scope for useful tree plantings. The land classes fenced off may separate saltland from good arable land. Belts of salt-tolerant trees just inside the salt paddock can help dewater the marginal land, mulch and shade the soil and act as a windbreak for the bare saltland. A fence between good arable land and deep erodible sandplain is often justified. It may be a good location for a two or three line windbreak to help control wind erosion.

Eucalyptus globulus and E. saligna in an agroforestry configuration.

Ridge crests are often ideal sites for shelterbelts for wind erosion control. Wind speeds are highest across exposed ridges. Laneways for stock and vehicle movement are often sited along ridges and being double-fenced, are ideal tree planting areas, provided they are not used for sheep movement during the establishment years.

Rocky outcrops and breakaways are often left uncleared and unfenced; they may show decline and no seedling regeneration. Double fencing of rocky outcrops is probably the cheapest way of getting more trees back on a farm. Fence off, maybe after a burn, and allow regeneration to occur naturally.

Contour banks with fences along them fit in with convenient contour working. To avoid too many strainer posts, small islands of land are often left between the bank and the fence. These pieces of 'dead' land are ideal for groups of trees; usually a single line could be planted along and below the bank. On exposed windward slopes, these midslope contour windbreaks can be valuable in preventing wind erosion.

Bigger banks built with a bulldozer may also provide 'islands' suitable for tree planting. Suitable tree species may be planted on top of the banks or just down-slope of them.

Most of the tree planting sites mentioned above are areas which are either non-arable or should not be cropped. **It is possible to plant many trees on properties implementing a conservation farm plan, without any significant loss of cropping land.** Tree fencing costs are only half those where a special double fence is needed to protect a windbreak not tied in with the paddock fence layout.

Crops and trees

Competition between trees and crops is minimized by locating trees on non-arable land with the arable land along one side of the belt. Root-pruning by ripping along the arable side of the belt can further reduce this problem. It may damage some trees, and should be practised as infrequently as possible.

To be compatible with large agricultural machinery, trees need to be aligned in belts and blocks and not as scattered individual trees or small clumps, as in the 'parkland' pattern of clearing. In any case, individual trees do not seem to thrive. There may be a case on mixed wheat and sheep farms for a few smaller well-treed, parkland paddocks for use by lambing ewes and off-shears sheep. These are often situated close to the house and sheds, where they provide additional shelter for the buildings and create an 'oasis' effect.

Other places where trees can be planted include awkward corners and spots of 'dead' ground, inaccessible to machines and sometimes sheep. Examples include islands of land isolated between deep gullies, acute corners where contour banks join waterways, and sharp paddock corners.

Plantings in and around the farm yards provide shade and shelter for stock and workers, and improve the homestead environment.

Windbreak plantings around dams may be justified to reduce wind speed over the water surface, lowering evaporation losses. They should not be planted too close to the dam and should be below the dam wall to reduce leaf litter and sheep manure pollution of the water.

On farms which grow cereals there may be conflict in locating tree belts where they give most benefit in erosion and salinity control, but are situated on fertile, well-drained soil, where they still compete with crops.

Trees for saltland

Advantages of trees

There are many reasons for wanting to plant trees on saltland, for example:

- to beautify an otherwise ugly piece of land;
- to convert a salty area into a future stock shelterbelt. Many farms were overcleared during development. In planning replanting programmes it makes good sense to use non-arable areas if trees will grow on them;
- tree belts help reduce wind erosion. Wind erosion, combined with sheep trampling on saltland, helps enlarge the areas of bare saltland;
- trees planted around the fringes of saltland may lower the watertable enough to avoid further spread of salinity.

Grade banks and graded mounds on saltland.

When the main reason for growing trees has been decided, the best varieties can be selected.

Planting trees is one part of dealing with saline areas; drainage in the salt affected area, earthworks above the site, and higher water use crops and pastures around the site will all help reduce the problem. Planting trees in isolation from the other treatments may give only a very small effect. Also consider the use of salt tolerant grasses and shrubs for fodder value between tree lines. This gives added erosion control and reduced surface salt accumulation.

Site preparation

Before the opening rains, rip 50 cm deep along the proposed tree lines; preferably two lines 50 cm apart. Then, on all salt affected or waterlogged sites, make a mound 25 to 30 cm high with a plough, road grader or a three point linkage blade on a tractor, or a specially built mounder. The mound will protect the seedling from flooding and aid root growth.

Ripping and mounding the soil will encourage the opening rains to leach salt before planting.

Grass competition on saltland is usually confined to low-growing barley grass, which does not shade out the young trees. There is little competition for soil moisture on saline sites, which are often very wet. Consequently it is unnecessary and even undesirable to spray herbicides to control weeds in most saline sites. Spraying the soil surface can increase the rate of salt accumulation in the topsoil.

Mounds may need weed control, especially on mildly affected areas. Pre-plant residual herbicides, or post planting selective grass herbicides can be used.

Species and varieties

A wide range of trees and plants will tolerate slight soil salinity but few plants and very few trees will tolerate saline and waterlogged soils. Soil or water analysis may show if waterlogging or salt is the main concern.

Severely saline sites

These sites are usually bare and are flooded in winter. Virtually no trees will grow on these sites. The best plant is samphire (*Halosarcia* spp.), which occurs naturally in salt lakes and creeks in Western Australia.

The large shrub, *Melaleuca thyoides*, has outstanding salt and waterlogging tolerance and is useful for shelter and appearance. Other species include *Melaleuca cymbifolia,* and *M. uncinata.*

Moderately saline sites

These sites usually have a patchy covering of barley grass (*Hordeum marinum*). The most salt-tolerant species should be planted here. They include:

- athel tree (*Tamarix aphylla*) the evergreen tamarisk which can be propagated easily from cuttings;
- spring flowering tamarisk (*T. gallica*) the deciduous species which can be propagated from cuttings;
- salt or swamp sheoak (*Casuarina obesa*) which is a good windbreak. It frequently spreads from self-

Eucalyptus occidentalis on mounds on saltland.

sown seed;

- flat-topped yate (*Eucalyptus occidentalis*);
- salt river gum (*E. sargentii*), grows slowly south of Perth and is usually shallow-rooted;
- *E. halophila*;
- coastal moort (*E. platypus* var. *heterophylla*); an excellent, low and attractive windbreak with fair salt tolerance;
- flooded gum (*E. rudis*); good flooding tolerance;
- *Melaleuca uncinata*; a useful bushy, low to medium sized tree;
- *Melaleuca cuticularis;* salt paper bark. Very good flooding tolerance.

Mildly saline sites

- York gum (*E. loxophleba*); a widespread shade tree of better wheatbelt soil types;
- river red gum (*E. camaldulensis*); good flooding tolerance. Some very salt tolerant types available;
- sugar gum (*E. cladocalyx*); not waterlogging tolerant.

Non saline fringes

Trees with high water use, suitable for the rainfall zone should be planted in a belt around the saltland. Examples for high rainfall areas include Tasmanian blue gum (*E. globulus*), Sydney blue gum (*E. saligna*) and spotted gum (*E. maculata*).

Planting

Plant the seedlings into a hole or furrow in the top of the mound and press the earth around the seedling to remove air pockets. Gently water in with fresh water if necessary.

Layout and design

Trees to lower the water table can be planted to intercept water before it reaches the discharge area or planted directly on or adjacent to the problem area, or planted to stop recharge directly on recharge zones. Planting on watertable recharge areas allows more species to be selected from, and often coincides well with other farm planning requirements (see chapter 'Fitting trees into the farm plan'). These sites are generally along gravelly or rocky ridges and deep sand areas.

Planting on or near saline discharge areas (seeps, gully sides, salt flats) gives a direct and possibly rapid effect on the local watertable. Tree survival and growth may be lower on these sites.

Tree numbers to give the desired result have been estimated by rough rules of thumb. This needs some assumptions about the amount of water a tree uses each year and the flow rate of water in the soil. Contact a Department of Agriculture soil conservation adviser for details.

For recharge areas, trees need to be evenly distributed for best results. Interception planting (lateral water movement) needs to be wider on sandy surfaced soils and narrower on heavy loams. That is, more lines of trees on sandy soils.

Planting on flat salt areas to lower the watertable: trees can be in single or double lines spaced across the site. The distance between lines is determined by the soil conductivity (to water) and the speed of a desired change.

Fencing

Fence the area to protect seedlings from grazing animals. Rabbit netting or baits may be necessary to prevent rabbit damage and individual tree guards will ward off parrots.

Watch for damage by insect pests and control with the appropriate insecticide.

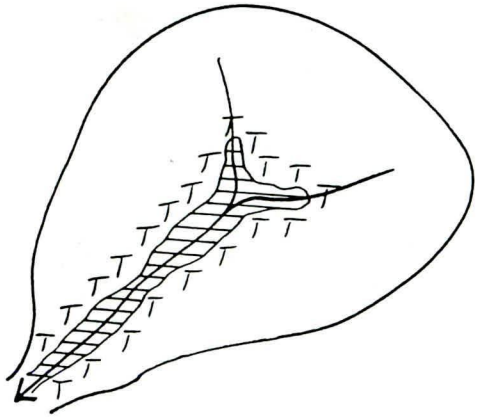
Watering

Apart from fresh water at planting, water only if the trees wilt. Normally, there is adequate water in salty areas and plants die because of flooding rather than a lack of water.

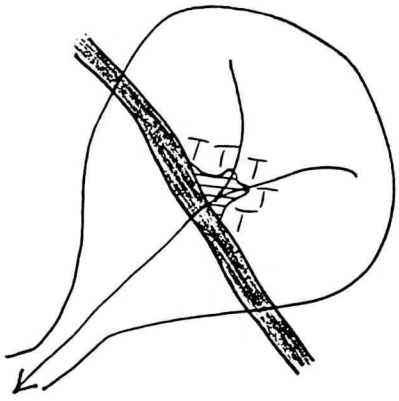
Intercepting groundwater

T = trees

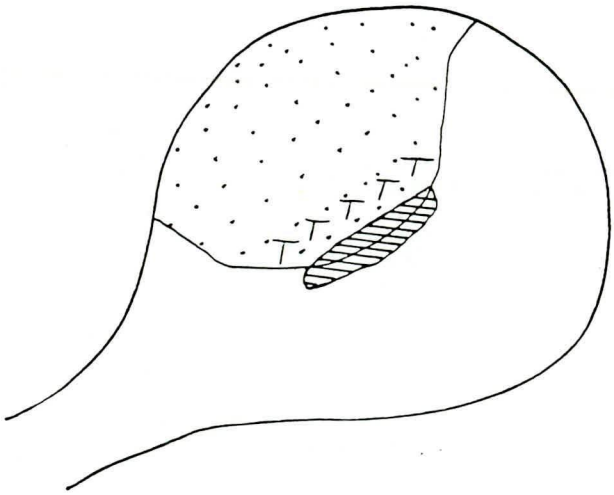
1. Valley salinity



2. Dykes



3. Sand seep

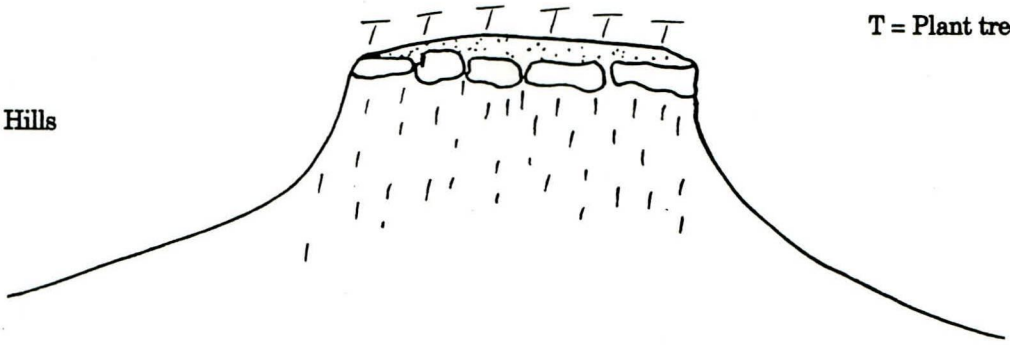


Sites for tree planting to intercept groundwater.

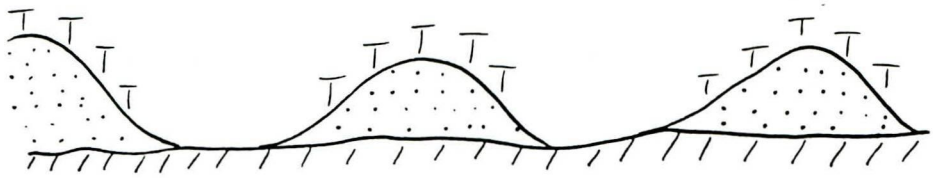
Reducing recharge

T = Plant trees

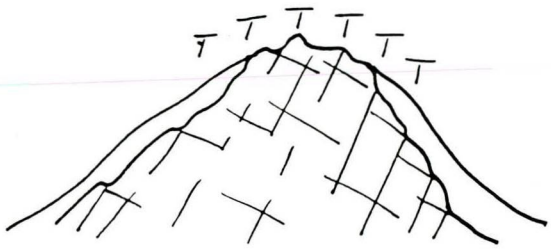
1. Mallet Hills



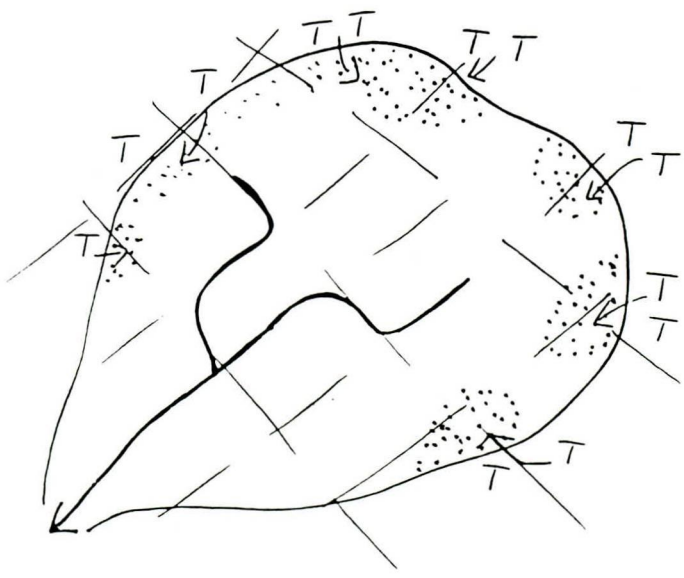
2. Sand dunes



3. Fractured rock



4. Deep sand and shear zones



Sites for tree planting to reduce recharge.

Trees in wet areas

Very few trees will grow in areas that are continuously waterlogged. Therefore the first consideration in reclaiming a wet area is to reduce the amount of water coming into and staying in that area. Earthworks (grade, diversion/interceptor banks and dams) can be used to limit water entry into the area and various drainage systems will reduce the accumulation of water.

Contour (grade) ridging may be necessary to give seedlings a chance to develop in a moist, but not wet, environment - once established, trees can cope better with 'wet feet'. The ridges (on top of rip lines) will also allow leaching of salt that often accumulates in the surface layer of wet areas - the ridging/ripping may need to be done a season before planting in badly affected areas.

When the preparatory work is complete, the area will need to be fenced off - to protect seedlings and to prevent 'pugging'. Electric fencing is the cheapest form and is effective. (See Western Australian Department of Agriculture Bulletin 4131).

For those farmers interested in monitoring the effects of their reclamation/tree planting efforts, several auger holes dug to 2 to 3 m, with slotted 40 to 50 mm P.V.C. pipe inserted, will allow easy measurement of the water-table level and also allow water sampling for salinity tests. Make sure the pipes have lids to prevent rain creating false readings. In areas which are badly salt-affected, it is a good idea to do this first, so that appropriate work can be done and suitable tree species can be chosen. For information on preparation and planting see other appropriate chapters in this book.

The trees selected are a matter of personal choice within the limits set by the site characteristics. The main aim of the exercise is to lower the watertable (to about 2 m depth) and where a large amount of water is present, planting of closely spaced, high water use trees, will achieve this. A closely planted 1 ha plot of well established eucalypts (e.g. *E. globulus*) is estimated to use 20,000 cubic metres of water in a year. To achieve the best effect, spacing should be in the range of 4 m by 4 m (625 plants/ha) to 4 m by 2 m (1,250 plants/ha). Species such as *Acacia melanoxylon* (Tasmanian or southern blackwood) may be planted between rows of one year-old eucalypts - they appear to thrive on the competition and grow quickly and very straight.

Species chosen for their timber may be thinned as they mature to allow for a better end product. Replacement planting is a good idea before mature trees are removed. Poplars and willows may be pruned or coppiced for fodder, and some (particularly hybrid varieties) have been successfully grown alongside salt-affected areas.

The following table provides a list of trees suitable for wet areas - divisions are according to salt tolerance or particular characteristics. These categories are not intended to be definitive - species/tree performance varies considerably and depends on the trees origin (provenance) and what is recognized as 'salt' conditions.

Salt tolerant	Moderately salt tolerant	Slightly salt tolerant
(bare areas - with patchy covering of barley grass [*Hordeum marinum*])	(thick covering of barley grass)	(areas of barley grass amongst other grasses)
Eucalpytus: *occidentalis* *sargentii* *spathulata* *platypus* (var. *heterophylla)*	*Eucalyptus:* *camaldulensis* *campaspe* *cornuta* *conferruminata* *macrandra* *robusta*	*Eucalyptus:* *calophylla* *globulus* *gomphocephala* *leucoxylon* *maculata* *muellerana*
Melaleuca: *cuticularis* *thyoidies* *rhaphiophylla* *uncinata*	*rudis* *Acacia melanoxylon* (and others)	*ovata* *patens* *saligna*
Casuarina obesa	*Populus alba*	
Tamarix: *aphylla (articulata)* *pentandra* *gallica*		
Populus euphrates		

Non-saline areas	Noted for high water usage	Fast growth rate
Eucalyptus: *mannifera* *microcorys* *regnans* *tereticornis* *torquata* *viminalis* *woolsiana*	*Eucalyptus:* *botryoides* *globulus* *leucoxylon* *maculata* *mannifera* *muellerana* 'Mysore' (hybrid: *camaldulensis* / *tereticornis)* *regnans*	*Eucalyptus:* *botryoides* *globulus* *conferruminata* *muellerana* *resinifera* *saligna* *viminalis* *Acacia melanoxylon*
Populus: semi-evergreen hybrids *Salix babylonica,* *vitellina* (var. *pendula)*	*saligna* *sideroxylon* *tereticornis* *woolsiana* *wandoo* *Populus* species *Salix*	*Populus species*

Sources of assistance

Department of Conservation and Land Management

This organization has two specialist officers available to assist in all aspects of tree planting and management. They can also supply seed and seedlings at moderate cost and they have a good array of leaflets.

There are offices in many major country centres where advice can be obtained.

Department of Agriculture

They can be of assistance in general queries on trees, their use on the farm, agroforestry and insect control.

There are offices at Bridgetown, Manjimup, Narrogin, Katanning, Bunbury, Albany, Jerramungup, Lake Grace, Busselton, Harvey, Northam, Merredin, Moora, Geraldton, Three Springs and Esperance.

Greening Australia

This group encourages tree planting. Grants and information are available for revegetation and tree planting schemes. For example, a group of farmers at Jerramungup received a grant to revegetate their farms after a bushfire.

The group administers the John Tonkin Tree Awards to encourage community involvement in trees.

The 'One Billion Trees' programme is also administered by Greening Australia. Annual grants will be available over the next ten years to individual farmers or to Land Conservation District Committees.

Greening Australia also supply trees under their 'Ribbons of Green' programme to revegetate major roads in the city and the country.

They produce a newsletter 'Leaflet' which contains much useful information.

Greening Australia have taken over the operation of the Hamel Nursery.

Greening Australia, Unit 5, Leederville Village, 106 Oxford Street, Leederville 6007, telephone (09) 227 5771.

Australian Forest Development Institute

The Institute can provide details on contractors for commercial forests, as well as arrange insurance for pine plantations.

Their address is Australian Forest Development Institute, Western Chapter, 103 Colin Street, West Perth 6005, telephone (09) 322 2088.

Bunnings Tree Farms Pty. Ltd.

They can be a useful source of information, seedlings and contracts. (See chapter on 'Sharefarming schemes').

Contact: Mr J Sanders, Bunnings Tree Farms Pty Ltd, Manjimup 6258.

Local nurseries

Nurseries and tree planting contractors are located throughout the farming area. These people can supply information on tree selection and planting techniques.

Tax and farm trees

Trees for conservation

Soil conservation

Expenses for establishing shelterbelts and/or windbreaks specifically for the purpose of preventing or combating soil erosion on farms, are deductible in the year of expenditure.

The cost of clearing virgin land or indigenous vegetation no longer attracts any taxation concession.

Shelter, windbreaks and fodder

Expenditure on tree plantations for the purpose of shade, visual improvement, water quality, flora and fauna reserves, education and scientific research, is of a capital nature and is not deductible.

The replacement of any such trees destroyed (e.g. by fire or disease) before the exhaustion of their useful life, would be considered a maintenance expense and is therefore deductible.

However, crop trees (such as apples or tagasaste) which are replaced due to exhaustion of their natural life, are considered to be capital and therefore not deductible.

Maintenance costs such as fertilizing, vermin and weed control, are fully deductible business expenses (Section 51).

Fencing

Construction of a new fence is normally regarded as a structural improvement and as such qualifies for depreciation at 4.5 per cent diminishing value for ordinary fences and 7.5 per cent for electric fencing.

The cost of erecting or extending erosion control fences to exclude livestock or vermin from areas affected by erosion or salinity, is deductible in the year of expenditure (Section 75D).

Trees for income

The definition of forest operations within the context of primary production, if done by the owner who is a primary producer, covers:

- planting trees in plantations or forests intended for felling;
- tending trees in plantation or forests intended for felling;
- felling of trees in a plantation or forest;
- transport of the felled trees for processing. If carting or felling is done by a contractor, this does not apply.

As these expenses are incurred in the generation of income, they are fully deductible, as are the normal maintenance costs. This applies to primary production only.

Standing trees not trading stock

The value of a standing tree crop is not brought to account for the purpose of calculating taxable profit, as is done for livestock. Trees only become trading stock when severed from the land.

Sale of timber

Income from the sale of forest produce is assessable whatever the method of sale if the product has been grown for the purposes of making profits.

This indicates that early documentation of intentions from the outset of a farm programme, such as in a comprehensive farm plan, may prove useful evidence of intent in later years.

However, regardless of the person's intention at the time of acquiring land, once **regular** sales of timber are made, the proceeds are assessable income.

Where a person plants timber for another purpose, for example extensive windbreaks, and makes a **once only** sale, these proceeds may be free of tax.

What if an existing timber stand is purchased?

If purchased with the intention of making profits, proceeds may be included in assessable income. If the new owner did not purchase land with the intention of selling existing stands of timber for profit, the proceeds may not be in the nature of assessable income.

Sales of timber from forests or native stands managed primarily for grazing, may not be regarded as assessable income.

Where a farm forestry operation is planned and carried out for commercial purposes, the tax situation is clearer than for many of the farm uses of trees discussed here.

Criteria which may be used to determine whether or not proceeds from timber sales are assessable income include:

- market price;
- purchaser - farmer, friend or sawmill;
- extent of operation;
- quantity per sale;
- extent of professionalism of enterprise.

This information on tax and farm trees reflects the taxation laws as they currently stand (April 1991). Should you require further detailed information, specific enquiries can be directed to the Deputy Commissioner of Taxation, by you, or through your accountant/tax agent.

Pines - wood for the future

The profitability of growing pine is increasing. Softwood, produced by pines, has a number of advantages over native hardwoods: it is fast growing, light, has a high strength to weight ratio; it is easy to work and nail; and cheaper than hardwood to transport. Although subject to insect attack and rot, the timber may be treated with preservatives and used for any building or outdoor work. It is also used in furniture, cabinet making and veneers.

Only the south-west is suitable for fast growing commercial plantations. Farmers contemplating significant areas of pines should consult with Department of Conservation and Land Management officers regarding site suitability.

Growing pines

Which pine?

Experimental plantings of various pine species throughout the south-west have demonstrated that there are two species suitable for management as plantations in Western Australia.

These are *Pinus radiata* from California and *Pinus pinaster* from the coastal areas of Portugal and France. Each species has characteristics which make it suitable for different areas in the state.

Pinus radiata is the faster growing of the two, and at present provides most of the softwood milled in Western Australia. It does, however, require a deep, fertile loam for best growth and has mainly been planted in the major river valleys of the south-west, such as the Blackwood Valley between Bridgetown and Nannup.

Pinus pinaster can be grown in less fertile soils, and successful plantations have been established on the coastal sand plains near Perth. This species also needs less water than *P. radiata*, but is slower growing. One characteristic of the species that bodes well for the future is that it may be grown on very poor soils, with the use of phosphate fertilizers.

How?

Pine in Western Australia is grown commercially on a 30 year cycle or 'rotation'. At different stages in the rotation, the plantation must be tended in order to encourage maximum growth and ensure high quality timber. At the same time, the plantation will yield certain products. The yield or volume of wood produced by the plantation depends primarily on rainfall, fertility, and management regime.

Where?

There are three factors that must be considered before planting pines:

- Rainfall: both *P. radiata* and *P. pinaster* require a minimum rainfall of 700 mm to maintain an accept-

Agroforestry demonstration site. The pasture between the tree rows was grazed and cut for hay.

Pruning lower branches - an essential part of high quality timber production.

able growth rate for commercial timber production. Both species may be grown in areas of lower rainfall, but will produce less timber.

- Soils: *Pinus radiata* grows best on the more fertile soils such as red loam and red loamy-gravels, but may be grown on yellow sand and some lateritic sands with the addition of fertilizers.

Pinus pinaster grows well on both yellow and grey sand, but requires fertilizing.

- Markets: transportation costs will obviously affect the profitability of your venture and in most cases, distances of more than 70 km from your expected market, will be uneconomic.

The type of timber you produce will also affect your market. Most mills have minimum specifications for the logs they will accept.

Managing your plantation

Year -1 to 0

Site preparation

Site preparation is essential to eliminate all competing vegetation. The planting site should be cleared and burnt, and then ploughed, unless the site is already pasture. Where ploughing is not feasible, scrub control may be assisted by means of herbicides.

External firebreaks are essential and these must be kept clear by annual maintenance. Most shire authorities who have been involved with pines have specific requirements for plantation firebreaks.

Planting

Pine seedlings are raised in the nurseries from seed sown direct into the soil. When removed for planting, the seedlings are open-rooted and their roots must be protected and kept moist. Planting is carried out during the months of June and July when the soil is thoroughly wet. In wet areas mound planting may be necessary, while in the drier coastal sand plain north of Perth, 'furrow lining' is practised, to maximize moisture retention. If required, fertilizer should be applied and clover sown at the time of planting. On some soil types establishing clover at this time will greatly improve soil fertility and ensure continued good growth of the pines.

Pines are planted relatively close to each other to prevent excessive branch development, and to provide for later selection of well formed trees. The spacings currently recommended vary from 3 m x 2.5 m (1,330 trees/ha) to 3 m x 3.25 m (1,000 trees/ha). It is essential to eliminate all competing weed growth in the first year.

Tending your plantation

A pine plantation requires considerable attention throughout its life to maintain it in a healthy condition, and to promote the production of high quality timber. In some instances, on the less fertile sites, refertilization may be necessary.

The various management activities needed to achieve and maintain a healthy, vigorous, productive pine plantation are as follows.

Years 1 to 3

Scrub control

Regrowth of native scrub, eucalypt coppice, or grass compete with pines for moisture and nutrients. Left unchecked, they can severely impair pine growth rates. Control of this regrowth is usually necessary in the early years. This can be carried out by the use of herbicides, slashing, or cultivation.

Years 3 to 10

Pruning

Unlike most eucalypts, pine trees retain their lower limbs, and this results in the formation of knots which lower the quality of the timber. To produce timber free of knots, the lower limbs must be removed by pruning. Initially, all standing trees should be

Pine products, specifications and markets (1984)

Products	Specifications		Markets
	Diameter	Length	
Small pine round logs (small end under bark [u.b.])	7 to 20 cm	1.8 to 4.8 m	Bunbury, Bridgetown and Mundijong
Logs for particleboard (small end u.b.) large end not to exceed 30 to 35 cm u.b.	7.5 to 15 cm	2.7 to 5.4 m	Metropolitan and Dardanup
Case logs, etc. (small end u.b.)	13 to 20 cm	2.1 to 2.7 m	Metropolitan, Balingup, Nannup Bridgetown and Dardanup
Mill logs (for high quality sawn timber)	Not less than 20 cm (small end u.b.)	2.1 to 4.8 m	Metro., Grimwade Dardanup and Pemberton
Peeler logs (for high quality veneers)	Not less than 35 cm(small end u.b.)	Variable up to 2.6 m (as nominated by buyer)	Metropolitan

Anyone wishing to sell pine logs should discuss the required specifications with the buyer.

pruned to 2 m above ground level. This provides easy access generally, but particularly for fire control. Subsequent prunings are generally restricted to trees selected as crop trees.

Pruning is usually done with secateurs, hand saws or mechanical equipment. The height to which the stems are pruned and the number of trees selected for pruning is the decision of the owner or manager. However, severe pruning can inhibit the vigour of the trees. At least one-third of the tree's total height should be left as green branches.

Years 9 to 20

Thinning

The intensity and frequency of thinnings, and the length of rotation adopted, depend on market opportunities and the type of product required. In Western Australia the opportunities for selling small logs are limited and the commonly accepted aim is to grow high quality sawlogs in the shortest possible time. This is achieved by non-commercial early thinning, thus reducing the number of trees to the final crop early in the rotation. Given access to markets, the early thinnings and tops of later thinnings will produce fence posts and wood for manufacture into particle-board.

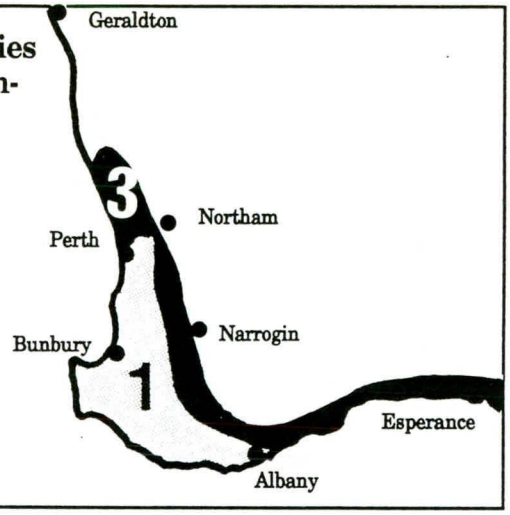
Thinning is a most critical operation especially on drought prone sites. If thinning is delayed, drought deaths can occur about Year 12, if dry summers are prevalent. When drought deaths do occur, the plantation manager loses the choice of which trees to retain for his final crop. His crop trees are also placed under stress, and will grow slowly.

Fire

Uncontrolled fires kill pine trees. It is essential that adequate measure be taken for the early detection and suppression of fires in, or close to the pine plantation.

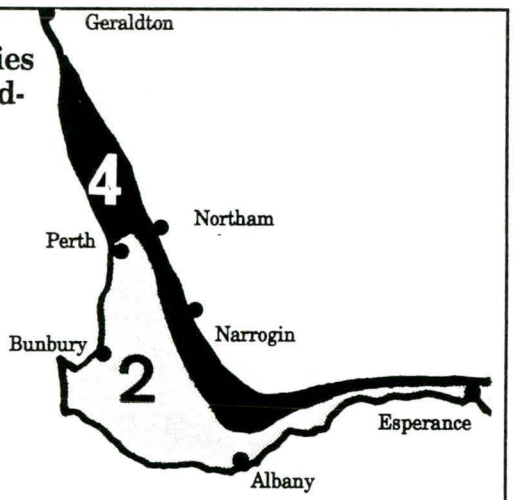
Firebreaks and roads must be maintained yearly to the standards and specifications of the local Shire. Insurance is available through the Australian Forest Development Institute which represents private forest growing interests in Australia. Further information can be obtained from the West Australian Chapter, P.O. Box 254, West Perth 6005.

Approximate boundaries for plantations—assuming correct soil type.



Zone 1—P. radiata
Zone 1 & 3—P. pinaster

Approximate boundaries for agroforestry & windbreaks



Zone 2—P. radiata
Zone 2 & 4—P.pinaster

Species	Purpose	Zone	Minimum Rainfall Requirements	Soils
P. radiata	Planatations	1	750mm/year for areas of high summer evaporation. 600mm/year for low summer evaporation.	Suitable soil types for both species are moisture retentive (not waterlogged) yellow sand, gravel sands and soil should be penetrable to a depth of at leat 60cm inceasing to more than 1m in lower rainfall zones. Pinus radiata more fertile soils.
	Agroforestry & Windbreak (inc. timber)	1,2	650mm/year for areas of high summer evaporation. 500mm/year for areas of low summer evaporation.	
P. pinaster	Plantations	1,2,3,	600/year for areas of high summer evaporation. 500mm/year for areas of low summer evaporation.	
	Agroforestry & Windbreak (inc. timber)	1,2,3,4,	500mm/year for areas of high summer evaporation. 450mm/year for areas of low summer evaportation.	

Exotics for special purposes

Fodder and timber

Carob

The carob is a tough evergreen tree from the Middle East. It produces dense shade and heavy crops of sugary pods - an average of 1 t/ha from trees planted on 15 m centres. It needs 350 mm of annual rainfall or alternatively it needs to be planted near contour banks or areas which receive run-off. Deep taproots will sometimes find underground water. Both male and female trees are required for pod production, this has been achieved in Western Australia in four years with well managed trees. Young trees are susceptible to frost and are fickle to establish. Good results have been obtained at frost prone Balingup by protecting the trees with clear plastic tubes from topless/bottomless Urea bags held up by three stakes.

Sandalwood

This valuable native tree has all but disappeared from the populated south-west because of commercial exploitation. At present day prices of $600/tonne and no synthetic substitute, it would appear a good investment. Plantings have been successful in bushland and have grown to minimum commercial size in 20 years. The trees are root parasites and need hosts, preferably wattles. Preferred soils are sands/loams over clays. There seems no reason why these trees could not be grown along with wattles as the bushy component of shelter-belts. The trees are highly palatable to livestock but because of their high wood value are best not used as fodder trees.

Acacias (wattles)

Acacias share many of the attributes of tagasaste (tree lucerne). On the other hand many wattles are longer lived, more drought resistant, and have high levels of tannin in the bark which render them less susceptible to ringbarking. Bushy forms are ideal for the low component of shelter-belts. It is essential, particularly in eucalypt dominant belts, to prevent wind from funnelling underneath the main canopy. Under natural conditions eucalypts obtain their nitrogen from that fixed by wattles. Not planting wattles alongside gums is akin to not planting clovers into a pasture.

Honey locust

These trees cast only very light shade allowing pastures to grow to the butt of the tree. Like the carob, a pod bearer, but with a high protein content. These trees are also either male or female, with only the females producing pods. They need summer rainfall or summer ground moisture to do well.

Kurrajong

These beautiful Australian natives have been dubbed the living silo and have been extensively planted in the drier parts of New South Wales for emergency drought fodder. Though slow growing in their early stages, they speed up after some years. They develop an enormous tuberous root system somewhat like a giant carrot. This food reserve enables the trees to recover quickly from being lopped for fodder. Adaptable to most sites, these trees need 400 mm of annual rainfall to do well or alternatively they need to be planted where they receive additional run-off. The slower growing desert kurrajong will grow even in the driest parts of the wheatbelt.

Blackwood and black walnut

These two trees have excellent potential to produce most valuable furniture timber on wet sites in the higher rainfall areas. Black walnut is legendary for its fine figured timber grain and blackwood is perhaps the next best thing and is widely planted in New Zealand as a timber crop on farms. Both trees need careful management to produce good timber form with expected rotation lengths of 35 years on agroforestry type management systems. Black walnut needs fertile sites whilst blackwood is nitrogen fixing and can grow on somewhat poorer soils.

Oaks

There are many good reasons for growing oaks as farm trees. They are strong growing, adaptable, almost fireproof, produce excellent shade for stock, and drop acorns for fodder, just when they are needed in the autumn.

Acorns are high energy food, rich in fat and carbohydrate. Warming food which drops as the weather turns cold, when the livestock have used up their reserves of body fat from the spring. Sheep, cattle, goats, horses and of course pigs, will all eagerly consume the acorn. By using different varieties an acorn drop extending from early March to early June can be achieved.

Contrary to legend, oaks are not slow growers, particularly in Australian conditions. One English oak at Balingup at 37 years was 28 metres tall and

A cork oak.

3.3 metres girth at breast height. They are, however, slow for the first few years, then once they have their roots established, take off quickly.

The English oak is best suited to the wetter areas, 500 millimetres or more of rainfall, though it may grow where there is adequate soil moisture in drier areas. This tree is one of the main oaks of timber commerce and, in general, carries a heavier crop of acorns than the cork oak. It prefers heavy soils and in its natural habitat, grows in stiff clays. However, it will grow in moist sands. It is deciduous.

The cork oak is at home in a mediterranean climate and is quite happy in poor dry soils, down to around 375 millimetres (15 inches) rainfall, although, of course, in those conditions it grows more slowly. In its native country, Portugal, its bark is first peeled for cork at about age 20 years and then subsequently every six to eight years. The first stripping of virgin cork yields material suitable for insulation. The quality improves with each stripping, the bark growing back finer each time. The poorer the soil, the better the cork. This tree prefers light soils, but will grow quite well on loams. It is an evergreen.

We have found cork oaks most easy to establish at Balingup with 100 per cent success being the norm. English oaks have proved harder to establish. Whilst not dying outright, they become subject to insect attack - a clear sign of stress. Normally the seedlings would start life in a shady humid environment and the summer sun and dry easterly winds of an Australian paddock are quite different. However, once established the trees are strong growers.

The trees can be expected to commence bearing acorns at five to ten years and, depending on conditions, will continue to do so for a very long time. In Europe, oaks live for 400 years or more and, whilst there has not been the opportunity to observe for this long in Australian conditions, ones planted in the 1840s are still going strong.

As they grow into large trees, wide spacings would be the most suitable. It could perhaps be beneficial to interplant with a fast growing legume for the early years, for example, tree lucerne or wattles. These could provided both nitrogen and a more equable microclimate for the oaks, as well as being capable of being lopped for livestock fodder and ultimately producing firewood.

The pin oak, red oak and scarlet oak, all produce spectacular autumn colours. The pin oak will grow in wet soils. All three are suitable for only the wetter, cooler, south-west corner. When possible, we grow ilex oak and Turkey oak, both suitable for hotter drier areas. Chestnuts, close oak relatives, are faster growing and earlier bearing, produce durable poles on a seven year coppice rotation and produce nuts for human and livestock fodder.

Willows and poplars for salt and waterlogging control

Because willows and poplars tolerate waterlogged conditions and transpire large amounts of water they offer opportunities to control waterlogged and saline soils - at the same time they provide summer and autumn greenfeed for livestock. The trees can be used to lower the watertable so that groundwater no longer rises to the surface leaving behind salt as it evaporates. Without the salt, and with improved drainage, grasses can establish on these sites.

The suckering, salt tolerant poplars of of particular use in this situation. They can be planted on the margins of barley grass areas and on 'islands' in scalded areas. As the water table is lowered the suckering root systems of the trees should spread into the scale recolonizing it. Livestock can be turned on to browse these suckers, a nutritious mineral rich feed, several times during the summer and autumn.

Correct management of grazing pressure will keep the suckers short (up to say knee high) so that the stock can make direct use of this feed without any more effort from the farmer than opening and closing the gate.

The large crowns of the parent trees will provide the nutrients for rapid leaf growth on the suckers so that they will be ready for another grazing. If more large trees are required then a drum, with top and bottom removed, can be placed around a sucker. When the sucker is large enough the drum can be shifted to another sucker further into the area which is being reclaimed.

Whilst saltbushes, samphires and associated perennial shrubs offer excellent browse from saline areas they are, by their succulent habit, inherently low water users. However, there seems to be no reason why these can not be grown in combination with an overstorey of suckering poplars.

In badly waterlogged conditions, willows may be more suitable than poplars but they suffer the disadvantage of not suckering - this limits the amount of fodder that the animals can browse directly. In these conditions the low growing, bushy, multi-stemmed osier or basket willow might be of advantage.

Tagasaste - tree lucerne

Tagasaste, or tree lucerne (*Chamaecytisus palmensis*) is a native of the Canary Islands. It is a hardy leguminous shrub or tree growing to a height and crown diameter of about five metres, often with long drooping leafy branches. White, pea-like flowers are borne in clusters at the ends of short branches.

Tagasaste grows most vigorously on well drained, fertile soils in high rainfall areas, but will tolerate a wide range of climatic conditions, soil types and fertility. On the fringe of bushland, the growth is normally retarded because of poor fertility and competition for water and light from the native vegetation.

Uses

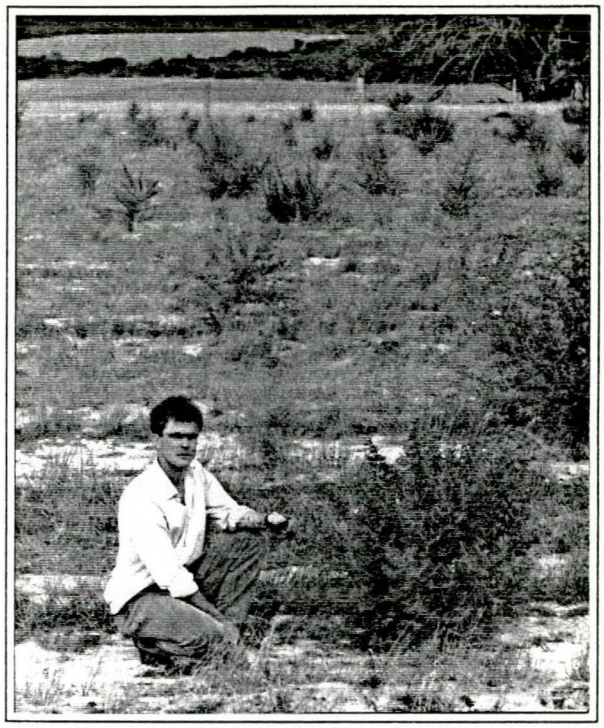
The increasing popularity of planting trees on farms has renewed interest in tagasaste.

Some of the uses and benefits being promoted for the species are:

- as a productive source of fodder and seed for livestock and poultry;
- an aesthetically attractive tree for roadside, driveways and homestead privacy;
- shelter for buildings and livestock;
- colonizer of stony and waste areas;
- windbreak for sensitive horticultural trees and crops and a possible source of nitrogen;
- control of soil erosion by wind and water;
- reduction in salinity through water consumption and lowering of the water table;
- a restorer of fertility to impoverished soils through nitrogen fixation and nutrient recycling;
- a source of pollen and nectar for bees during winter when other flowers are scarce;
- a haven for birds which are beneficial in controlling plant pests; and
- as a source of firewood.

Fodder value

Attention has been focussed on tagasaste because of its potential as a fodder tree, particularly on deep sands where pasture production is poor and often unprofitable.



An open stand, planted as seedlings six months previously.

Yield

Research by Dr L.C. Snook in Western Australia in the 1940s and 1950s and recently in New Zealand indicated yields of edible dry matter of 11 tonnes per hectare per year can be obtained from dryland tagasaste.

Quality

Nutritive value depends on the type of material sampled, maturity and the proportion of leaf to stem, as is indicated by samples analysed from trees from Bridgetown and Bokerup (70 km east of Manjimup).

With crude protein levels as high as 310 g/kg and digestibilities in excess of 65 per cent tagasaste is comparable with lucerne for protein and energy values.

Minerals

Trees which have received dressings of superphosphate have adequate calcium and phosphorus for animal production.

A few analyses have indicated that tagasaste can have low levels of sodium and copper, particularly during summer, limited experimental work has been unable to substantiate that, in a paddock situation, supplementation will improve animal production.

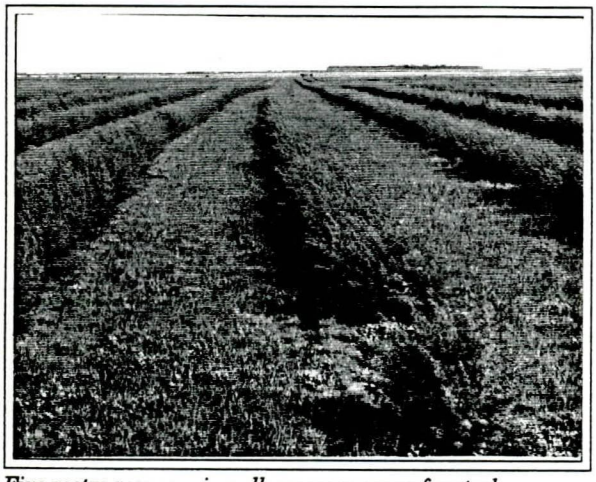
While cutting trials and quality analyses indicate that tagasaste may have high potential as a fodder tree this needs to be confirmed by conversion into economic livestock production.

The results of grazing experiments are discussed later in the section 'Livestock production'.

Establishment

Seed supplies

Tagasaste produces heavy crops of seeds which ripen in December. The seed pods can be stripped from the branches in December or early January prior to shattering. Pods spread out on black plastic



Five metre row spacing allows easy access for stock and machinery.

sheets in the hot sun will shatter readily, releasing the seed. Seed still attached to the pods can be freed by vigorous shaking in a plastic bag.

On a large scale, seed can be separated from sun dried material which has been crushed by a tractor and then passed through a harvester.

There can be strain differences within and between stands of trees, therefore seed should be collected from vigorous trees only.

Seed is available from seed merchants; prices range from $30 to $50 per kilogram.

Germination

Seed collected from trees will, without treatment to break seed dormancy, have a germination of only three to four per cent. The most convenient and effective farm method for improving germination is to cover seed in a container with boiling water and allow to cool. A germination of 65 to 70 per cent can be achieved with this method.

Another technique, which has given similar results in laboratory tests, is to apply the boiling water treatment and soak for a half hour then dry the seeds in an oven at 80°C for one and a half hours. The advantage is that the seed can be sown when convenient. It is also unlikely to be physically damaged when mixed with superphosphate, as can occur with seed softened by longer soaking with the boiling water treatment.

Scarified seed can be obtained commercially with germination percentages of up to 99 per cent.

Inoculation

The need for inoculation of the seed with specific rhizobia (nitrogen fixing bacteria) for various soil types in different climatic situations is unclear. In many instances trees have been established without treatment because of the presence of suitable rhizobia in the soil. However, there may be situations where nodulation will not be effective and the trees will fail to establish.

An inoculum is available commercially from seed merchants or Root Nodule Pty Ltd, Woy Woy, NSW. One packet will treat 50 kg of seed. Inoculated seed mixed with superphosphate must be lime pelleted.

Seedlings

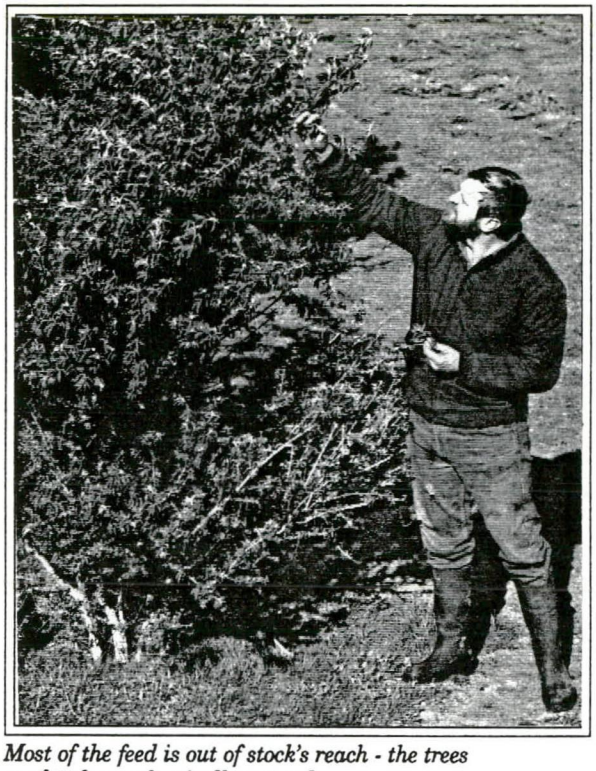
Various nurseries advertise the sale of seedlings. Orders should be placed well ahead of the anticipated planting date to ensure availability of suitable plants.

Seedlings can be purchased either bare rooted or in cell packs. Prices vary from as low as 10 cents to more than 50 cents each.

Seedlings should be inspected to ensure they are not root bound as trees which subsequently develop will be prone to uprooting by winds.

Planting should be into soft, moist ground, preferably ripped, care being taken to compact the earth around the seedling.

A pre plant knockdown and residual herbicide treatment should be applied and fertilizer banded with, or applied alongside, the seedlings.



Most of the feed is out of stock's reach - the trees need to be mechanically pruned.

Planting as soon as the break of the season is assured will provide maximum opportunity for survival.

Direct seeding

For large areas this is the most practicable and economical method. Successful establishment can be achieved by sowing through one or a number of runs of a seed drill.

After the boiling water treatment seed should be mixed with a dry base and sown immediately.

Inoculated and lime pelleted seed can be mixed conveniently with superphosphate.

More precise sowing can be obtained by using tractor-mounted, row seeders. Machines equipped with a fertilizer box are an advantage as they allow banding of the fertilizer alongside or beneath the seed.

Seeders are available which incorporate features such as, a scraper for weed control, variable sowing spacings and depth, press wheel for soil compaction after sowing, fertilizer applicator, subsoil ripper, coulter for trash control and detergent application for non wetting sand. Prices are in excess of $10,000.

For small areas an efficient, manually operated machine is the Earthway, Model 1001-B seeder. With a fertilizer box, the price is around $280.

Depth of sowing should be around 10 mm and no deeper than 25 mm. The deeper sowing should only be used where there are doubts about soil moisture retention around germination, particularly in medium to low rainfall areas.

Germination is likely to be affected when seeds are sown at greater depth.

Ground preparation

Ripping

In limited trial work, ripping has not been found beneficial for direct seeding. Where it may be beneficial is in sandy soils which have developed a hardpan through frequent cropping. In these situations ripping to at least a half metre is advised. Rip lines should be compacted prior to sowing for satisfactory depth control and to eliminate air pockets. On heavier soils, multiple row ripping prior to seeding, followed by heavy rain, can cause bogging problems during the seeding operation.

Cultivation

This will be determined by the previous use and condition of the land, for example, new or old land, cropped or pastured, level or rough. A scarifying followed by harrowing is normally adequate to achieve a level friable seed bed.

Cultivation of sandy soils should be minimal to avoid wind erosion and sand blasting of seedlings.

Sowing strips of cereals, such as cereal rye, adjacent to tagasaste rows may be required to reduce sandblasting. Sow with a nitrogen/phosphorus compound fertilizer to stimulate rapid early growth to obtain seedling protection.

Sowing in a minimum tillage operation, especially after cropping, is possible provided that care is taken in controlling sowing depth.

For reliable germination and establishment it is essential to compact the sowing line after sowing. At New Norcia, a 300 per cent increase in trees was recorded at 12 months when a tractor was driven down the seed bed after sowing.

Weed control

Weeds must be controlled to minimize competition for moisture and nutrients. This is unlikely to be achieved without the combined use of cultivation and herbicides, except on new land.

Suitable contact herbicides for application prior to sowing and two to four weeks after the break of season are Spray.Seed® and Roundup®, at normal recommended rates.

More research is required to identify safe pre and post emergence residual herbicides, in relation to soil types, particularly sands. Contact your local Department of Agriculture for the latest advice on herbicides suitable for tagasaste.

Water repellent soils

Frequently sandy soils fail to wet evenly at the break of season, resulting in patchy germination and establishment. These water repellent properties can be overcome by spraying specially formulated wetting agents in narrow bands over the sowing lines.

Two products are Aquasoil® and Wetta Soil®. A suggested rate of application is 20 L/ha (in the sprayed band), sprayed immediately after sowing.

Sowing/planting time

This should be as early as is practicable within the constraints of adequate soil moisture for germination and establishment and satisfactory weed control.

In low rainfall areas, early sowing is particularly important, to provide the greatest opportunity for seedling survival over summer.

Use of pre and post emergence herbicide treatments permits sowing at or near the break of the season.

On forest soils in high rainfall areas (above 550 mm) experience has shown that sowings as late as August can be successful, provided weed control is adequate.

Fertilizers

As tagasaste is a legume, nitrogen applications should be unnecessary for rapid growth, provided nodulation is effective.

Other fertilizer requirements will depend on soil type and past fertilizer history.

Only limited research has been conducted to determine requirements and, until these become clearer, fertilizer recommendations for pastures should be applied to tagasaste. These should include copper, zinc and molybdenum where normally recommended for new land sowings and on old land where the history of application is uncertain.

Banding of superphosphate is likely to be beneficial, particularly on new land and will help to control competition. Lime pelleted seed should be sown where banding is adopted.

Care should be taken not to overdo rates when banding fertilizer in a normal drilling operation. For example, the equivalent of 200 kg/ha drilled by combine is only 3.5 kilograms per kilometre of row.

Potash should not be banded with seed because of likely toxic effects.

On deep sand at New Norcia experiments showed that deep placement of fertilizer (100 to 250 mm) in the year of sowing, at 25 kilograms per kilometre of row, increased the yield of edible dry matter of 15 month old Tagasaste by 30 per cent.

Shallower placement at 50 to 100 mm decreased seedling survival through toxicity.

A suggested preparation and sowing procedure is:

- cultivate and harrow where necessary;
- rip and deep fertilize;
- compact rip line;
- spray knockdown and residual herbicides;
- scalp soil from sowing line;
- precision seed or sow by combine;
- press wheel to compact sowing line;
- spray wetting agent to sowing line; or
- spray residual pre emergent herbicide.

Soil types and sites

Tagasaste grows well on a wide range of well drained and non saline soils. It grows remarkably well on ironstone hills and breakaways and on deep sands which fail to support productive crops or pastures. The tree does not tolerate waterlogging. Perched water tables in wet seasons have caused the death of mature stands. Best yields are obtained from summer moist but well drained, deep sands, such as occur on the south coast at Esperance.

Planting patterns and tree density

The most practicable and economic method of utilizing tagasaste is by grazing animals with minimal machine thinning and harvesting.

Planting patterns should be designed with these points in mind and to try to maximize yield of herbage through rotational grazing.

Experience has shown that a suitable pattern incorporates single rows five to six metres apart, allowing easy access by stock to both sides and convenient space for the passage of machinery for row trimming and top-dressing.

There seems little purpose in multiple close planted rows as the inner sides of these rows become inaccessible for grazing and present difficulties for top grazing and cutting.

There may be a case for close spaced (up to a metre) dense double rows where the hedge is used as a replacement for conventional sub division fencing. The interwoven thatch of branches of the rows, encouraged by topping, could possibly create an impenetrable barrier to grazing stock as a cheaper alternative to fencing.

Cropping

Experience has shown that patterns designed to allow both inter row cropping and grazing are not practicable. Wider inter row spacings are required for cropping machinery thereby reducing tagasaste yield. The extended deferred grazing during the cropping phase subsequently results in the need for heavy side and top pruning of thick branches to maintain row form.

Also, on deep sands where tagasaste grows well the economics generally does not favour cropping.

Row alignment

Where possible, alignment should be north-south, to maximize use of sunlight by trees and pasture, and at right angles to the prevailing winds to provide shelter and protection from wind erosion. Consideration should also be given to the effect of alignment on water erosion.

Water points

Gaps should be left within the rows about every 100 metres to allow stock easy access to water and other rows and to minimize mismothering of lambs.

To minimize costs for water points, locate troughs in raceways providing common access to adjoining paddocks of tagasaste grazed on a rotational basis.

Tree density

There is no information for Western Australia which relates tree density within rows and inter-row spacing to total yield under different environmental conditions. However, experience has indicated that it is unnecessary to exceed two to four trees per metre of row.

At each seed drop at least three seeds should be sown to account for germination failures and mortalities following germination. The seed requirement at the highest seeding rate would be about 350 grams per kilometre of row, or 700 grams per hectare, with a between row spacing of five metres.

Tree density at four per metre and a between row spacing of five metres would be 8,000 per hectare.

Management

Insect pests

During the establishment year control of insect pests is essential.

Regular monitoring of emerging seedlings for redlegged earth mite and cutworm is essential. Spraying should be carried out, using recommended insecticides, immediately damage is noted. Repeat spraying may be necessary.

During the first spring and summer spraying for budworm and Rutherglen bug and spraying and baiting for locusts and grasshoppers may be necessary, especially if ringbarking occurs.

Once established, tagasaste is relatively free of insect pests. Occasionally the tagasaste moth (*Uresiphita ornithopteralis*) will damage trees in the autumn. Spraying is not usually necessary but grubs can be controlled with carbaryl.

Stem borers may also attack trees, but damage is normally insignificant.

Vermin

Rabbit should be controlled in the summer preceding sowing as only a few rabbits can be very damaging to developing seedlings.

Tree training

The objective is to stimulate branching close to the ground so that tree production remains within grazing height of stock. This can be achieved by early grazing or cutting, or a combination of both.

Dense, low branching also helps protect trees from bark stripping by stock.

Grazing should be at high stocking rates for short periods to minimize physical damage. Trees should be a minimum of 25 to 30 cm tall before grazing.

Subsequent management should aim to maintain the pruned height at about 50 cm. This will be achieved without mechanical topping at some times, as stock never completely eat regrowth back to the old growth.

In young plantations conventional 'sickle bar' type hay mowers have been used successfully for topping.

Specialized cutting machinery, incorporating five contra rotating circular saw blades, is now available from Kimseeds for around $15,000. This is a robust machine capable of handling overgrown plantations. Operated by power take off the machine has an adjustable cutting angle.

The company also offers a contract pruning service at $120 per hour, plus a location fee. In an average well-managed plantation the travelling speed would be about 8 kilometres per hour.

A commercial 'sickle bar' type machine is being developed, but not yet available.

Grazing

Graze stands rotationally to allow recovery after grazing and minimize damage from bark stripping by stock.

Paddock sizes will depend on stock numbers, area and production of tagasaste and how it is to be used in relation to other feed sources on the farm.

Commercial producers have subdivided into paddocks ranging from 8 to 20 hectares for successful grazing management.

Tagasaste is likely to have greatest feed value during summer/autumn when all other paddock feed is dry and low in quality. Depending on productivity, however, trees may have to be grazed two or even three times per year to be kept under control. Multiple grazings will reduce total production. An experiment at New Norcia showed sheep grazing days were reduced by 40 per cent when tagasaste was grazed twice annually compared with once in the autumn.

Bark stripping

This has occurred in some instances, even where inter row feed or green tagasaste has been plentiful.

Freshly cut trees are most susceptible and wounds should be allowed to 'harden up' for several days before grazing. The wilted, cut material will be eaten readily by stock.

Protection of trees rows by fencing is impracticable and uneconomic. Successful management involves rotational grazing coupled with periodic mechanical pruning. Stock must be removed when leaf material has been eaten and before significant bark stripping occurs.

Subdivision fencing

Costs can be at least halved by the use of mains electric fencing. In a trial at Bokerup, with posts 50 metres apart and two droppers per span, a minimum of four wires (top and alternate live) were required to contain Merino ewes. An extra wire is needed for lamb proofing.

Livestock production

There is no doubt that in Western Australia on deep sands, which grow unproductive pastures, tagasaste can provide economical production.

This has been established by the Martindale Research Project of the University of Western Australia at New Norcia.

A 1988 trial showed that 900 adult trees per hectare produced 7,500 kg of edible green matter yielding 3,400 weaner sheep grazing days. The trees were allowed to grow ungrazed for 12 months and utilized in April/May.

For a normal 90 day grain feeding period 38 sheep could be fed on each hectare of tagasaste. This was calculated to be equivalent to a saving in 1988 of $137 per hectare as replacement grain feeding.

Over the two years 1986/87 and 1987/88 weaners grazed throughout the summer produced on average an extra 550 grams per head of clean fleece. Fibre diameter increased by 0.7 microns in 1986/87, but there was no difference in 1987/88 when compared with wool from flockmates grazing dry pasture.

The value of extra wool was $4.80 per head or $58 per hectare. Savings in grain feeding and pasture or stubble feed over the 210 days amounted to $72 giving a total value of $130 per hectare.

At Esperance farmers who have established extensive areas also report marked improvements in productivity on previously unproductive deep sands. An annual carrying capacity of 12 dry sheep per hectare has been achieved and higher levels are believed possible.

On heavier soils, which support productive subterranean clover based pasture, the potential for tagasaste has not been established by research.

At Bokerup (70 km east of Manjimup) in 550 to 600 mm rainfall zone, a large scale trial failed to show any benefit from tagasaste on predominantly gravel and gravelly loam soils. Double rows were sown one metre apart with an inter row spacing of 20 metres.

Breeding ewes were fed the tagasaste in the autumn-winter period but there were no benefits in bodyweight, fleece weight, lamb weaning percentage or weaning weight.

In an observation trial in the Wellington Dam catchment, no obvious increases in dry sheep bodyweights or wool production were recorded when compared with similar sheep on dry pasture. Tagasaste was fed for 49 days in the autumn.

Other uses

The potential for tagasaste to act as a pump to lower water tables for salinity control is currently being investigated.

Evapotranspiration was measured in December 1984 to June 1985 in the Wellington catchment where it was shown that tagasaste could possibly use twice as much water as lupins over a season.

Table 1. Nutritive value of tagasaste

Material	Sampling date	Crude protein (g/kg D.M.)	Digestibility %
Old bark	June	81 to 91	48 to 55
New bark	August	90	62
Tips from growth (not vigorous)	June	194	62
Tips from fresh growth with flower buds	Early August	198	65
Old growth with flowers	Early August	102	50
Growth from tips of young tree just prior to flowering. Stems up to 8 mm diameter	June	124	54
Fresh growth stems up to 5 mm thick Bokerup	Early August to late October	156 to 256 Average 176	67 to 77 Average 71.3

At Bokerup, drawdown of the water table has been inconclusive. Closer spacing of the trees rows may have given greater water usage.

A more comprehensive trial is now in operation at New Norcia.

Farmer experience at Dandaragan and Esperance has been that close spaced tagasaste rows have dried out adjoining wet and potentially saline sites below plantations.

Toxicity

Claims have been made that tagasaste has caused intoxication in horses, when eaten in the pod stage. Alkaloids could be the problem.

Nevertheless, it has been fed to sheep for extended periods without ill effect. No documented reports of toxicity in sheep, cattle, goats, deer or poultry have been cited.

Trees as fire protection

Planting trees near dwellings can increase the risk of fire. However, the risk can be reduced by careful selection of species.

Some trees are less flammable than others. Trees that have a reduced fire risk are those low in volatile oils, high in salts or high in moisture. Trees which have their lower limbs high above the ground (spotted gum) are hard to ignite. Trees with fibrous or stringy bark, for example, messmate and manna gum, ignite easily and fire can spread quickly. Wind can carry the burning bark to new fire sites.

Trees high in oil such as eucalypts, callistemons and paperbarks, can also increase fire risk.

The following list groups trees in order of decreasing fire resistance:

- salt accumulating plants, e.g. saltbush, tamarix, boobialla;
- deciduous trees, e.g. oaks, maples, elms, poplars, willows;
- evergreen hardwoods, e.g. peppercorn, pittosporum, mirror bush;
- introduced conifers, e.g. pines, firs, cypress, cedar;
- native shrubs, e.g. wattles, paperbarks, callistemons, grevilleas, hakeas, tea trees and banksias;
- eucalypts.

No matter how fire tolerant trees are, their tolerance is negated by poor maintenance.

Removing dry leaves, branches, litter and mulch, is critical to generating a safer area. The ground below the trees should be bare.

Trees and shrubs with low potential fire hazard

Introduced species

Acer campestre	common maple
Acer negundo	box elder maple
Acer platinoides	Norway maple
Acer pseudoplatanus	sycamore
Alnus jorulensis	evergreen alder
Calodendron capense	cape chestnut
Castanea dentata	American chestnut
Castanea sativa	sweet chestnut
Ceratonia siliqua	carob
Coprosma repens	mirror plant
Corynocarpus laevigatus	New Zealand laurel
Elaeagnus angustifolia	Russian olive
Fagus sylvatica	common beech
Elex aquilifolium	holly
Lagunaria patersonii	pyramid tree
Ligustrum spp.	privet species
Liriodendron tulipifera	tulip tree
Olea europaea	olive
Photinia glabra	red-leaf photima
Photinia serrulata	Chinese hawthorn
Pittosporum eugenioides	tarata
Prunus laurocerasus	cherry laurel
Prunus lusitanica	Portugal laurel
Quercus canariensis	Algerian oak
Quercus cerris	Turkey oak
Quercus ilex	holm oak
Quercus robur	English oak
Schinus molle	peppercorn tree
Tamarix aphylla	athel tree/tamarisk
Ulmus procera	English elm

Native species

Acacia baileyana	Cootamundra wattle
Acacia cyanophylla	western wattle
Acacia cyclops	W.A.coastal wattle
Acacia glandulicarpa	hairy pod wattle
Acacia howittii	sticky wattle
Acacia iteaphylla	Gawler range wattle
Acacia melanoxylon	blackwood
Acacia pravissima	Oven's acacia
Acacia prominens	golden rain wattle
Acacia terminalis	cedar wattle
Acacia vestita	hairy wattle
Casurina cunninghamiana	river sheoak
Eucalyptus maculata	spotted gum
Hakea salicifolia	willow hakea
Hakea sauveolens	sweet hakea
Melaleuca lanceolata	moonah
Myoporum insulare	common boobialla

Properly designed windbreaks can help in slowing and diverting the fire.

These aspects involve careful consideration of tree species, tree height, length and width of break, as well as alignment. An incorrect combination can cause a greater risk. The topic is too complex for details to be incorporated in this bulletin. If you have a specific requirement, the Bushfires Board and the Department of Conservation and Land Management can provide further details.

There is a very useful publication on 'Bush fire safety' available from the Bushfire Board of Western Australia, the Department of Agriculture or Shire offices.

Further reading

- Frances, Pat. Trees can save your farm from fire. Farm Magazine, November 1984, p. 74.
- Brennan, M. Bushfire risk in residential bushland regions. Australian Horticulture, December 1985.
- Brown, P. Living in a flammable landscape. Australian Horticulture, December 1985.
- Anon. (1987) Bushfire safety in urban fringe areas. Bushfire Board and Insurance Council of Australia.

Sharefarming schemes

Bunnings Treefarms private forestry

Bunnings Treefarms (formerly WACAP) has been actively encouraging landowners to plant eucalypts on their land since 1982 when a number of Tree Growing Incentive Schemes were initiated. These schemes have involved a total of about 160 landowners and 1,800 hectares up to the end of the 1990 planting season. The schemes generally involved the provision of free advice, seedlings and sometimes fertilizer in return for a right of first refusal to the paperwood harvested from the plantation.

The plantings established under these schemes consist primarily of Tasmanian blue gum (*E. globulus*). However smaller areas of other commercial eucalypts such as the eastern States flooded gum (*E. grandis*), Sydney blue gum (*E. saligna*), karri (*E. diversicolor*) and yellow stringybark (*E. muellerana*) have also been planted. Bunnings Treefarms believes that the Incentive Schemes have achieved their objective of stimulating general community interest in tree growing and is currently reviewing their structure.

Bunnings Treefarms plans to establish 3,500 hectares/year of Tasmanian blue gum plantations in the south-west of Western Australia over the next 10 years. Much of the land for these plantations is expected to be leased from landowners via a licence agreement. Under this agreement the landowners receive an annual licence fee (annuity) in return for granting Bunnings Treefarms a right to grow and remove timber from their land. The agreement covers two rotations and will last for 20 years on average.

To be accepted for a licence agreement land must total more than 20 hectares, be located within 120 kilometres of Bunbury or 100 kilometres of Manjimup, receive more than 700 millimetres of rainfall per year, have an acceptable soil type and have been cleared and pastured for at least five years. Apart from receiving the annual licence fee the landowner receives a share of both crops of timber as well as retaining the grazing rights under the plantation following establishment. Bunnings Treefarms is totally responsible for plantation establishment, access roads, insurance, maintenance and harvesting while the landowner is responsible for fencing and the payment of rates.

Bunnings Treefarms also sells a wide variety of seedlings at very reasonable prices to the general public. A total of 24 species of trees including 22 eucalypts are available in small peat (jiffy) pots. The trees can be ordered in September or October and are ready for picking up in the following June. Delivery anywhere in the State can be arranged if required through our contract nurseries. Bunnings Treefarms' forestry experts can advise on the correct choice of the tree species as well as providing advice on the correct establishment procedures.

Department of Conservation and Land Management

Softwood and hardwood sharefarming schemes are administered by the Department of Conservation and Land Management. Interested growers should contact the Department for up-to-date details of contracts which are available.

Suppliers

This is a list of some of the major suppliers of seeds, trees, contract services and revegetation equipment. As it has not been possible to identify every supplier, we apologise to those whose names are omitted.

As a rough guide to the products supplied, the letters after each name refer to:

E - eucalypts
P - pines
T - tagasaste seedlings
A - saltbush seedlings
D - deciduous trees
O - other tree species
S - seeds
M - machinery
C - contract services
F - conservation farm planning
V - vegetation consulting
W - pruning service

Agro Forestry (Aust.) - C
17 Greenshields Street
Albany 6330
Phone: (098) 41 6424

Australian Revegetation Corporation
(Kimseed) - S, M, C
51 King Edward Road
Osborne Park 6017
Phone: (09) 446 4377

Bunnings Tree Farms - E
Eastbourne Road
Manjimup 6258
Phone: (097) 71 1222

Chatfield's Tree Nursery - E, T, A, O, S, M, C
P.O. Box 3
Tammin 6409
Phone: (096) 37 1075

Crosby Bros. - W
1 Nelson Street
Bridgetown 6255
Phone: (097) 61 1147

Cunderdin Tree Nursery - E, A, O, S, C
127 Cubbine Street
Cunderdin 6407
Phone: (096) 35 1174

W.C. Diamond & Co - A, S, M, C
c/- Post Office
Maya 6614
Phone: (096) 64 2011

Earth Repair (David Vann) - E, T, O, S, C
RMB 1182
Denmark 6333
Phone: (098) 40 8043

Echidna Nursery - E, O
Graham Street
Albany 6330
Phone: (098) 41 6899

Fodder Shrub Industries (John Cook) - S, M, C, V
P.O. Box 25
Dandaragan 6507
Phone: (096) 52 8062

Geegelup Native Plants - E, O
P.O. Box 236
Bridgetown 6255
Phone: (097) 61 1163

Gidgegannup Nursery (Country Landscape) - E, P, T, O, M, C
Toodyay Road
Gidgegannup 6555
Phone: (095) 74 6163

Greening Australia Hamel Nursery - E, P, D, O
P.O. Box 147
Waroona 6215
Phone: (097) 33 1241, after hours 537 1360

Green Scene (Bev Hundley) - E, T, S, O, V
RMB 7055
Esperance 6450
Phone: (090) 76 8519

Harper Seed Co - S
Box 315
Cannington 6107
Phone: (098) 54 1065

K. & N. Contracting - C
P.O. Box 9
Tambellup 6320
Phone: (098) 25 1023

D.C. & J.M. Ingram - E, P, T
P.O. Box 264
Bridgetown 6255
Phone: (097) 64 3555

Dean Melvin - T, A, O, S, C
P.O. Box 155
Dowerin 6461
Phone: (096) 34 1024

Mitchell's Nursery - E, P, T, A, O, S, C
P.O. Box 47
Wickepin 6370
Phone: (098) 88 1066

Nindethana Seed Service - S
RMB 939
Woogenilup 6324
Phone: (098) 54 1066 or 54 1065

Nufab (Peter Nunn) - M
P.O. Box 171
Dongara 6525
Phone: (099) 27 1297

Prince Growers Tree Farm - E, O
P.O. Box 562
Northam 6401
Phone: (096) 22 2971

Rural Trees of W.A. - E, A, O
Warrigal Way
Chidlow 6556
Phone: (095) 72 4358

Rural Planning (Viv Read) - F
P.O. Box 809
South Perth 6151
Phone: (09) 367 6646

Small Tree Farm (Andrew Thamo) - E, P, D, O, S, C
P.O. Box 27
Balingup 6253
Phone: (097) 64 1113

Bob Stafford - C
Quindalup
Phone: (097) 55 1114

The Tree Planters (Cameron Caldwell) - C
10 Lobelia Drive
Greenmount 6056
Phone: (09) 299 6223

Total Saltland Treatments (Ashley Lewis) - E, S, C, F
RMB 126
East Wickepin 6370
Phone: (098) 88 6040

Walkaway Tree Planters - E, O, C
c/- Post Office
Walkaway 6528
Phone: (099) 26 1183

Wandoo Farmland Service (Dewe Vincent) - C
22 Goldsworthy Road
Esperance 6450
Phone: (090) 71 4149

Wendana Saltbush Nursery - A, M
P.O. Box 56
Gnowangerup 6335
Phone: (098) 22 1540

Department of CALM Nursery, Narrogin - E, O
P.O. Box 100
Narrogin 6312
Phone: (098) 81 1113

Department of CALM Nursery, Gnangara - P
980 Wanneroo Road
Wanneroo 6065
Phone: (09) 405 1222

Department of CALM Nursery, Manjimup - E (large orders only)
Brain Street
Manjimup 6258

Trees - integrate for sustainable profit

Trees can be a profitable enterprise in their own right, as well as providing shelter, land conservation, water quality and aesthetic benefits.

Tasmanian bluegums *(E. globulus)* show prospects of adding to farm profits in the areas west of Albany Highway and with annual rainfall at least 600 mm. By planting trees on farms as various forms of timberbelt these profits may be realized without greatly affecting livestock carrying capacity.

This chapter outlines the expected costs and returns from planting and managing bluegums for pulpwood. Some farmers, when armed with this information, are likely to find ways of blending a pulpwood enterprise with their other activities to enhance overall farm success. A number of farmers already have substantial plantings of bluegums an are looking to other potential end uses for the timber to achieve even higher returns.

Table 1. Typical bluegum establishment costs

Operation	Cost $/ha
Site and soil assessment	20
Mounding or ripping	50
Weed control	80
Planting and fertilizing	120
Plants	190
Fertilizer	30
Pest control	10
Total	500

Tree establishment

Good establishment of trees requires ground preparation, weed control, fertilizing and pest control. Each must be done in the right way at the right time to be effective, as there are no second chances. The right technique for each depends on the site. More detail can be found in the booklet 'Grow trees for profit' produced by the Department of Conservation and Land Management (CALM).

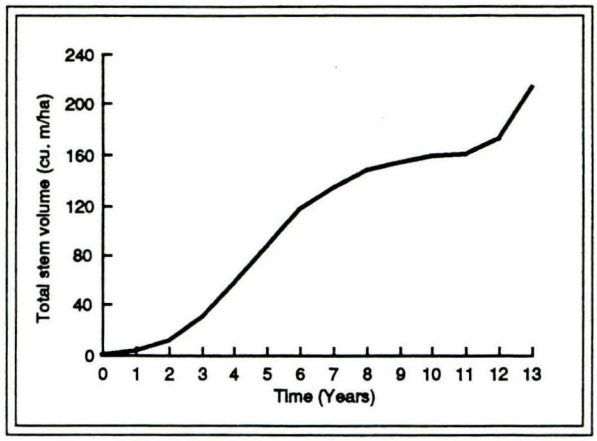


Figure 1. Total stem volume of E. globulus *on Stene's Farm, Wellington Catchment. (Data source: G. Inions pers. comm.)*

Typical costs are shown in Table 1, but these vary with the nature of the site.

The penalty for poor establishment can include partial replanting (by hand), higher weed control costs, increased fire hazard, slower growth and/or later harvest.

Maintenance

Other than firebreak maintenance, the main outlays are periodic applications of fertilizer, and a ground burn and yield assessment prior to each harvest.

After the first harvest, and again after the second cut, the trees are allowed to regrow from the stumps (coppice).

This coppice needs to be pruned (thinned) to limit the number of stems, after the first and second cuts. The final outlay is a clean-up operation to restore the land for replanting to whichever species is then appropriate.

Table 2 summarizes the maintenance costs for a typical block, as estimated by CALM researchers from their National Afforestation Programme investigations.

Given the high cost of the coppice thinning operation it may well be more profitable to actually replant, especially since superior trees should be available within 10 years.

Table 2. Typical bluegum maintenance costs

Operation	Year(s)	Cost/ha
Firebreaks	1-30	$20/year
Fertilize	3, 5, 7, 12, 14, 16, 22, 24, 26	$80/application
Prune/thin	11, 21	$200/operation
Burn under trees	8, 18, 28	$15/burn
Inventory	10, 20, 30	$20/operation
Clean-up	31	$100

Returns

Bluegum growth rates in the 600 to 800 mm rainfall zone are estimated to range between 150 and 220 cubic metres of wood per hectare per 10 years. A similar yield is expected from each rotation. This is based on measurements by CALM researchers of trees grown in this region during the 1980s, a period of below average rainfall.

Figure 1 shows the mean total stem volume of bluegums on Stene's Farm, in the Wellington Dam catchment (G. Inions, pers. comm., 1990). Wood production was slow at first, accelerating as the trees grew. Low growth rates in years 8 to 11 coincided with low rainfall. Rapid growth in year 13 coincided with higher rainfall (1988-89).

The most profitable age to harvest the wood might vary between 7 and 13 years depending on the growth pattern on a particular site. The cost of deferring the sale of progressively larger stocks on hand must be weighed against the benefit of each extra year's growth.

Although no market currently exists in the State for bluegum pulpwood, the price (stumpage) is predicted by CALM to be within the range $20 to $30 per cubic metre for standing bluegums. The stumpage is the price net of harvest and transport costs. This is much higher than the $10.29 per cubic metre currently paid for marri chipwood, but is believed to accurately reflect the value of 200 mm diameter bluegum stems.

At a yield of 200 cubic metres and a price of $25 per cubic metre, pulpwood revenue would be $5,000 per hectare in each of years 10, 20 and 30.

Livestock can not be grazed between the rows of trees during the first two or three years of each crop of pulpwood logs.

Profitability

The likely profitability of bluegums can be expressed as an equivalent net annual return per hectare. To do so, we discount future costs and returns to give a present lump sum value, then convert that to an annuity value. The choice of discount rate is significant, because the higher it is the less valuable are future sums of money.

If the cost of money is projected to be 18 per cent, and inflation 8 per cent, the real discount rate is 10 per cent.

Table 3. Net returns from grazing enterprises

Main product gross price	Pessimistic weaner beef 210 ¢/kg	Optimistic Merino wool 650 ¢/kg
Gross income	20.00	26.50
Per head costs	3.50	6.00
Fertilizer	3.00	3.00
Operator salary	3.00	3.00
Cost of livestock capital (10%)	3.50	1.50
Net return	7.00	13.00

Any benefits from grazing around the bluegums, shelter they provide, or a lowered water table, are additional to the direct financial returns from trees.

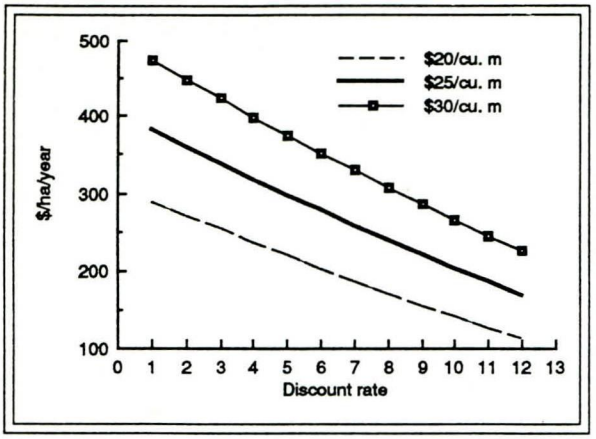


Figure 2. Net annual returns per annum for bluegums at various discount rates.

Figure 2 shows the annuitized returns at a range of discount rates, for bluegums priced at $20, $25 and $30 per cubic metre. The annuity exceeds $100 per hectare across the range of pulpwood prices and discount rates.

The per hectare annuity can be compared with expected agricultural returns.

Sheep and beef enterprises can be expected to return in the order of $7 to $13 per dry sheep equivalent (DSE) net of stock expenses, fertilizer, labour and livestock capital (see Table 3). At stocking rates typical for the 600 to 800 mm rainfall zone it would be unusual for net returns to exceed $100 per hectare.

Integrating trees and stock

To some extent trees and grazing enterprises complement one another; trees reduce wind speed and lower groundwater levels, livestock recycle nutrients and reduce the fire hazard.

There is also potential to reduce tree growing and transport costs by making use of farm machinery at times when it is not required, e.g. establishment, firebreaks, pruning, harvesting and backloading. Transport costs could also be reduced by drying the logs on farm from 50 per cent down to say 12 per cent moisture content, thus reducing their weight.

While it is useful to compare the two land uses as competitors, it is important to recognize their complementarity. A combination of livestock and trees promises the highest overall returns.

List of trees suitable for farm use

Key to uses

1 = Ornamental, 2 = Tannin production, 3 = Oils or perfumes, 4 = Honey or pollen, 5 = Timber or firewood, 6 = Salt tolerant
7 = Windbreak, 8 = Shade

Botanical name	Common name	Mature height (m)	Rainfall (mm)	Use	Comment
Acacia acuminata	Raspberry jam	5-8	<500	1,5,6,7,8	Adapted to N&E wheatbelt
Acacia baileyana	Cootamundra wattle	6-8	>500	1,4,5	Drought resistant
Acacia cyclops	W.A. coastal wattle	3	>500	6,7	Frost tolerant
Acacia dealbata	Silver wattle	10-15	>500	1,7,8	Suckers can be problem
Acacia decurrens	Black wattle	<15	>500	1,2,7	Fast grower
Acacia elata	Cedar wattle	20	>600	1,7	Prefers yellow sand subsoil
Acacia glandulicarp	Hairy pod wattle	2		1	Drought and frost resistant
Acacia howittii	Sticky wattle	6		7	Drought and frost tender
Acacia iteaphylla	Gawler range wattle	2-3	<500	1,7	Useful in two tier shelter belts
Acacia melanoxylon	Tasmanian blackwood	12-14	>500	1,5,7,8	Longer lived wattle
Acacia microbotrya	Manna gum	4-6	>400	1,2,4	Adapted to ridges short lived
Acacia podalyriaefolia	Queensland silver wattle	4-5	<500	1,7	Short lived
Acacia pravissima	Oven's acacia	6		1	Drought tender
Acacia prominens	Golden rain wattle	6		1	Needs shade, drought and frost resistant
Acacia pycnantha	Golden wattle	4-6	<500	1,2,4	Adapted to ridges
Acacia saligna	Golden wreath wattle	<10	>350	1,7	Waterlogged areas
Acacia terminalis	Sunshine wattle	2-3		1	Drought resistant
Acacia vestita	Hairy wattle	4			
Acer campestra	Common maple	20		1,8	Deciduous
Acer negundo	Box elder maple	20		1,8	Alkaline soils, drought tender, deciduous
Acer platinoides	Norway maple	30		1,8	
Acer pseudoplatanus	Sycamore	15-20	>500	1,8	Deciduous, frost tender
Acmena smithii	Lilly pilly	18		1	Drought and frost resistant
Agonis flexuosa	W.A. peppermint	6-9	>400	1,8	Not frost tolerant
Alnus jorulensis	Evergreen alder	8		1	Frost and drought tender
Angophora costata	Smooth-barked apple-myrtle	<25	>600	1,5	Poor areas
Araucaria excelsa	Norfolk Island pine	30	>600		Coastal areas
Brachychiton acerifolium	Illawarra flame tree	20-25	>500	1,8	Frost tender, drought resistant
Brachychiton populneum	Kurrajong	8-16	>500	1,4,8	Grows on range of soils, prefers loams
Brachychiton gregorii	Desert kurrajong	4-8	<400	1,8	Grows under severe conditions, very slow grower
Callistemon phoeniceus	Lesser bottlebrush	3	>500	1,7	Heavy soils, moist, salt tolerant, drought and frost tender
Callitris endlicheri	Black cypress pine	10-20	<500	1,5,7	Slow grower
Callitris huegelii	White cypress pine	10	<500	1,7	Drought, frost resistant
Callitris preissii	Rottnest Island pine	6-9	>500	1,7	Excellent low shelter, slow early growth
Calodendron capense	Cape chestnut	12		1	
Castanea dentata	American chestnut	30		1	Deciduous, drought tender
Castanea sativa	Sweet chestnut	25		11	Deciduous, drought tender
Casuarina cunninghamiana	River sheoak	12+	>600	1,7,8	Will grow in drier areas on wet sights

Table contd. . .

List of trees

Botanical name	Common name	Mature height (m)	Rainfall (mm)	Use	Comment
Casuaraina decaisneana	Desert oak	15	<400	1	Very drought tolerant
Casuarina huegeliana	Rock oak	6-9	<400	1,8	Grows on difficult sites
Casuarina obesa	WA swamp or salt sheoak	12	<500	5,6	Heavy flats
Ceratonia siliqua	Carob bean	6-9	>400	1	Fodder tree (pods)
Chamaecytisus proliferus	Tagasaste (tree lucerne)	3-5	>450	1,7	Fast growth fodder
Cinnamomum camphora	Camphor laurel	10-30	>750	1,8	Adapted to moist soils and conditions
Coprosma repens	Mirror plant	3		1	Good coastal species
Corynocarpus laevigatus	New Zealand laurel	6			Drought and frost tender
Cupressus arizonica	Arizona cypress	20	>300	1,7	Drought and frost resistant
Elaeagnus angustifolia	Russian olive	5			Full sun, drought and frost resistant
Eucalpytus accedens	Powderbark wandoo	25	>500	1,4,5	For gravelly soils
Eucalyptus angulosa	Ridge-fruited mallee	6	<500	7	Good for sand and soil conservation
Eucalyptus annulata	Open-fruited mallee		>500	4	Useful small tree
Eucalyptus astringens	Brown mallet	15	400+	1,8	Shade value decreases with age
Eucalyptus bicostata	Eurabbie	20+	>500	1,7	Heavy soil, drought and frost resistant
Eucalyptus botryoides	Southern mahogany	10-20	>600	1,4,5,7	Better sands and well drained soils
Eucalyptus brockwayi	Dundas mahogany	15-24	<400	1,4,5,7	Prefers light soils
Eucalyptus burdettiana	Burdett gum	2-4		1,4	Prefers light soil, frost tender
Eucalyptus burracoppinensis	Burracoppin mallee	3-6	<500	1,4,5	Very adaptable
Eucalyptus caesia	Gungurru or silver princess (large flowered form)	6-8	<500	1	Very adaptable
Eucalyptus calcicola	Bushy moort	2	>500	7	Coastal
Eucalyptus calophylla	Marri, red gum	35+	>500	1,4,5,7	Better sands
Eucalyptus calophylla (v. rosea)	Pink flowered marri	35+	>500	1,4,5,7	Better sands
Eucalyptus camaldulensis	River red gum	10-50	>400	1,4,5,6,7	Widespread and adaptable
Eucalyptus campaspe	Silver (topped) gimlet	8-12	>400	1,4,5,6	Adaptable
Eucalyptus cinerea	Mealy stringybark	10+	>600	1,7	
Eucalyptus citriodora	Lemon-scented gum	25+	>500	1,3,4,5	Light soils
Eucalyptus cladocalyx	Sugar gum	25+	>400	1,2,5,7	Light soils, toxic to stock
Eucalyptus cladocalyx (v. nana)	Dwarf sugar gum	10	>300	1,2,5,7	Light soils, toxic to stock
Eucalyptus conferruminata	Bushy yate	10	>400	1,2,7	Very adaptable, drought tolerant
Eucalyptus cornuta	Yate	20	>500	7	Adaptable
Eucalyptus crebra	Narrow-leafed ironbark	20-30	>500	1,5,7	Heavy soils
Eucalyptus crucis	Southern Cross silver mallee	5	>200	1	Hardy
Eucalyptus decipiens	Limestone marlock (Redheart)	13	>500	1	Very adaptable
Eucalyptus desmondensis	Desmond mallee	5	<500	1	Light and heavy soils
Eucalyptus dielsii	Cap-fruited mallee	4-6		1	Well drained soil
Eucalyptus diptera	Two-winged (bastard) gimlet	6	<500	7	Some salt tolerance
Eucalyptus diversicolor	Karri	80	>600	1,4,5,7	Prefers loam soil types
Eucalyptus dongarraensis	Dongarra mallee	8	<500	1,7	Prefers sandy soils
Eucalyptus doratoxylon	Spearwood mallee	2-5	>500	7,8	Prefers protected sites
Eucalyptus drummondii	Drummond's gum	8	<500	1,4,5	Useful shrub on light soils

Table contd. . .

List of trees

Botanical name	Common name	Mature height (m)	Rainfall (mm)	Use	Comment
Eucalyptus dundasii	Dundas blackbutt	20	<500	1,4,5,7	Prefers lighter soils
Eucalyptus ebbanoensis	Sandplain mallee	5	<500	1,7	Small tree
Eucalyptus eremophila	Tall sand (Goldfields) mallee	4-6	>250	1	Sandy soils
Eucalyptus erythrocorys	Illyarrie	5-8	<500	1	Showy ornamental
Eucalyptus erthyronema	White (red flowered) mallee	3-6	<500	1,2	Heavier soils
Eucalyptus ewartiana	Ewart's mallee	6	<500	1,4,5	Bushy mallee for sandy areas
Eucalyptus falcata	Silver or white mallet	10	<500	1,2,5	Very adaptable, mallee and tree forms
Eucalyptus ficifolia	Red flowered gum	5	>500	1	Restricted to southern areas
Eucalyptus flocktoniae	Merrit	10-13	>400	1,2,4,5,6,7	Adaptable
Eucalyptus foecunda	Narrow-leaved red mallee	2-5	<500	1,4	Very adaptable
Eucalyptus forrestiana	Fuchsia mallee	3-6	<400	1,6	Suitable for Salmon Gums and southwards
Eucalyptus gardneri	Blue mallet	10-12	>400	1,2,4,5	Very adaptable
Eucalyptus globulus	Tasmanian blue gum	20+	>600	1,5,7	Well drained soils. Fast growth
Eucalyptus gomphocephala	Tuart	15-35	>600	1,4,5,7	Very adaptable, best on limeston soils
Eucalyptus gracilis	Yorrel	8-12	>300	1,4,5,6,7	Very adaptable
Eucalyptus kochii	Watheroo mallee	8-10	<500	1,3,4,5	Adaptable, prefers sandy soils
Eucalyptus kondininensis	Kondinin blackbutt	12-20	>300	1,5,6,7	Adaptable and salt tolerant
Eucalyptus kruseana	Book leaf mallee	2-5	>200	1	
Eucalyptus landsowneana	Crimson mallee box	6	<500	1,5	Adaptable
Eucalyptus lehmannii	Lehmann's mallee	2-10	>400	7,8	Ideal for windbreaks
Eucalyptus leptophylla	Slender leaf white mallee	5	>300	1,7	
Eucalyptus leptopoda	Tammin mallee		<500	1,4,5	Prefers sandy area
Eucalyptus leucoxylon	Yellow gum	10-20	>500	1,2,3,4,5,7	Grows over 1 m/year on favourable sites
Eucalyptus leucoxylon *(v. rosea)*	Pink flowered yellow gum	10-20	>500	1,2,3,4,5,7	
Eucalyptus longicornis	Red morrel	10-22	>500	1,4,5	Very adaptable
Eucalyptus loxophleba	York gum	5-12	>300	1,4,5,6	Very adaptable
Eucalyptus macrandra	Long-flowered marlock	3	<500	1,4,6,7	Very adaptable and hardy
Eucalyptus macrocarpa	Mottlecah	2-5	<500	1	Pruning develops a dense shrub
Eucalyptus maculata	Spotted gum	20+	>600	1,4,5,7	Prefers better sands
Eucalyptus mannifera	Brittle gum	15	>100	1,8	Well drained soils
Eucalyptus marginata	Jarrah	15+	>600	1,4,5,7,8	Heavier soils
Eucalyptus megacarpa	Bullich	1.5-3		1 (8, tree form)	Tree form develops in wetter areas
Eucalyptus melliodora	Yellow box	20-30	>400	1,4,5,7	Best honey box
Eucalyptus microcorys	Tallow wood	20+	>600	1,4,5	Loams
Eucalyptus microtheca	Coolibah (flooded box)	18-24	>300	1,5,7,8	Very adaptable
Eucalyptus muellerana	Yellow stringybark	20+	>600	5,7	Medium to heavy soils
Eucalyptus nicholii	Nichol's gum	30	>600	7	Most soils
Eucayptus nutans	Red flowered moort	3	>400	1	Sandy loams
Eucalyptus occidentalis	Flat topped or swamp yate	20-25	>350	1,2,4,5,6,7	Very adaptable
Eucalyptus oldfieldii	Oldfield's mallee	4	<500	1,4	Well drained soils, drought tender
Eucalyptus oleosa *(var. kochii)*	Watheroo mallee	10-13	>300	1,3,4,5,6,7	
Eucalyptus oleosa					

Table contd. . .

Botanical name	Common name	Mature height (m)	Rainfall (mm)	Use	Comment
(var. oleosa)	Giant mallee	10-13	>300	1,3,4,5,6,7	
Eucalyptus ovata	Swamp gum	22		1	
Eucalyptus patens	W.A. blackbutt (Yarri)	45	>600	7	Moist subsoil
Eucalyptus platypus	Moort	3-8	>400	1,2,4,5,6,7	Very adaptable, prefers heavy soils
Eucalyptus platypus *(var. heterophylla)*	Coastal moort	3-8	<500	1,7,8	Heavy soils
Eucalyptus preissiana	Bell-fruited mallee	1.5-2	>500	1	Grows in poor soils, very adaptable
Eucalyptus pyriformis	Pear-fruited mallee	3-4	<500	1,4,5	Best on light soils
Eucalyptus redunca *(var. melanophloia)*	Black-barked marlock	10	>400	1,4,5,7	Adaptable dense mallee
Eucalyptus regnans	Mountain ash	60+			
Eucalyptus resinifera	Red mahogany	20+	>800	7	
Eucalyptus rhodantha	Rose mallee	1-2.5	<500	1	Straggling, of great beauty
Eucalyptus robusta	Swamp mahogany	15-25	>500	1,4,5,7	Best on wetter sites
Eucalyptus rudis	WA flooded or blue gum	10+	>500	1,4,5	Tolerates wet areas
Eucalyptus saligna	Sydney blum gum	20+	>600	1,5,7	Fertile loams and gravels
Eucalyptus salmonophloia	Salmon gum	12-25	>300	1,2,3,4,5,6	Adaptable and widespread
Eucalyptus salubris	Gimlet	13-20	>300	1,2,4,5,6	Heavier loams
Eucalyptus sargentii	Salt river gum	8-11	>350	1,2,6,7	Very salt tolerant
Eucalyptus sheathiana	Ribbon barked mallee	8	<500	1,4	Best on light soils, drought tolerant
Eucalyptus sieberi	Silvertop ash	20+		1	
Eucalyptus sideroxylon *(v. rosea)*	Red ironbark	20-30	>400	1,2,3,4,5	Very adaptable
Eucalyptus spathulata	Swamp mallet	5-8	>300	1,2,6,7	Very salt tolerant
Eucalyptus stoatei	Scarlet pear gum	6-8	>300	1	
Eucalyptus stricklandii	Yellow flowered blackbutt (Strickland gum)	7-8	<500	1,4,5,6	Light soils
Eucalyptus tereticornis	Forest red gum	40		1	
Eucalyptus tetragona	Tallerack or silver marlock	2-8	<500	1	Light soils
Eucalyptus todtiana	Coastal blackbutt	6	>400	1,4,5	Lighter soils
Eucalyptus torquata	Coral gum	6-8	>300	1,4,5,6	Well drained soils, ideal for coast
Eucalyptus transcontinentalis	Redwood	15-20	<500	1,4,5	Light soils
Eucalyptus viminalis	Manna ribbon gum	20+	>500	1,7	
Eucalyptus wandoo	Wandoo or white gum	15-20	>400	1,2,4,5	Very adaptable
Eucalyptus woodwardii	Lemon flowered gum	12-15	<500	1	
Eucalyptus woolsiana	Grey box	8-25	>400	1,5,8	Heavier soils
Fagus sylvatica	Common beech	30		1,8	Deciduous, alkaline soils,suckers
Ficus macrophylla	Moreton Bay fig	15+	>500	1,7	
Gleditsia triacanthos	Honey locust	20	>500	1,7	Suckers freely, has large thorns
Grevillea robusta	Silky oak	20	>100	1	Coastal
Hakea bucculenta	Red pokers	5	>200	1	
Hakea laurina	Pincushion hakea	5	>300	1,7	
Hakea multilineata		5	>200	1	Light soils, open position

Table contd. . .

Botanical name	Common name	Mature height (m)	Rainfall (mm)	Use	Comment
Hakea salicifolia	Willow hakea	3-4		1	
Hakea sauveolens	Sweet hakea	3		1	
Ilex aquilifolium	Holly	15		1	
Jacaranda mimosifolia	Jacaranda	8-12	>500	1,8	
Kunzea baxteri	Baxter's kunzea	2-3		1	Frost tender, light soils
Lagunaria patersonii	Norfolk Island hibiscus	10+	>500	1,4	Hairs in fruit cause itching
Leptospermum laevigatum	Victorian ti-tree	5-10	<500	1,7	Lower level of windbreak, can become a pest in coastal regions
Ligustrum spp.	Privet species	1-12		1	
Liriodendron tulpifera	Tulip tree				
Lophostemon confertus	Brush or Queensland box	10		1,8	
Melaleuca armillaris	Bracelet honey myrtle	3-5	<500	1,7	Lower level of shelter belt
Melaleuca cuticularis	Salt water paperbark	5		1	Waterlogged, semi-saline light soils
Melaleuca hamulosa		5	>300	1	Heavier soils
Melaleuca lanceolata	Moonah/Rottnest Island ti tree	4-6	>300	1,6	Very hardy, very salt tolerant
Melaleuca leucadendron	Long-leaved paperbark	22	650	7	Adaptable
Melaleuca nesophila	Western tea myrtle	3		1,7	
Melaleuca rhaphiophylla	Swamp paperbark	6		1	Good moist soil plant
Melaleuca thyoides				1,6	Salt and waterlogging tolerant
Melaleuca uncinata	Broom honey myrtle	3		1,4,7	Used for brush fences, moist soils
Melia azderach	Cape lilac / white cedar	15-45	>500	1,8	Fruit toxic to pigs and poultry
Myoporum insulare	Boobialla	4	>500	7	Tolerates drought
Olea europaea	Olive	5-8	>400	1,7,8	Fruit crop edible after treatment
Photinia glabra	Chinese hawthorn	3		1	Drought tender
Pinus brutia	Calabrian pine	20	>400	8	Coastal
Pinus canariensis	Canary Island pine	20+	>400	5,7,8	Slow growth, long lived
Pinus halepensis	Aleppo pine	12-24	>450	5,7,8	Very adaptable
Pinus pinaster	Maritime pine	15-30	>500	5,7	Sandy soils
Pinus pinea	Stone pine	15-18	>450	1,8	Will grow in drier areas
Pinus radiata	Monterey pine	to 40	>600	5,7	Fast growth
Pittosporum eugenioides	Tarata	6	>300	1	
Pittosporum phyllyraeoides	Weeping pittosporum	3-8	>400	1	Seed is easy to germinate
Platanus occidentalis	Plane tree (American sycamore)		20	>600	1 Deciduous
Populus alba	White poplar	30		1,7	Deciduous, open position
Populus nigra (italica)	Lombardy poplar	30	>600	1,7	Moist areas
Prunus laurocerasus	Cherry laurel	7		1	Drought and frost tender
Prunus lusitanica	Portugal laurel	6		1	Light to medium soils

Table contd. . .

List of trees

Botanical name	Common name	Mature height (m)	Rainfall (mm)	Use	Comment
Quercus canariensis	Algerian oak	25		1	Medium to heavy soils
Quercus cerris	Turkey oak	35		1	Deciduous
Quercus ilex	Holm oak	25		1	Drought and frost tender
Quercus robur	English oak	30		1	Deciduous, well drained alkaline soils
Salix babylonica	Weeping willow	10	>600	1,8	Needs lots of water, can cause dam and drain problems
Santalum spicatum	Sandalwood	8		1,3,5	Parasitic plant, slow grower
Schinus molle	Pepper tree	14	>200	8	Most soils, drier areas
Tamarix aphylla	Athel tree/tamarisk	10	>150	1,7,8	Good arid area tree
Tamarix articulata	Evergreen tamarisk	8-12	>300	1,7	
Tamarix gallica	Spring flowering tamarisk	6		1	Deciduous
Ulmus procera	English elm	30		1	Deciduous
Virgilia capensis	Virgilia	20	>750	1	Can be short lived

Key to uses

1 = Ornamental, 2 = Tannin production, 3 = Oils or perfumes, 4 = Honey or pollen, 5 = Timber or firewood, 6 = Salt tolerant
7 = Windbreak, 8 = Shade

Farmnote
No. 4/91

Western Australian Department of Agriculture

Agdex 131/22
Long term pastures/sowing

Establishing perennials in areas with less than 700 mm rainfall

By Ian Maling, Research Officer, Katanning

In areas that usually grow annual pastures, perennial pasture plants may be needed to stabilize soils, lower water tables and provide out-of-season feed.

Since these perennials will be sown into harsh environments, you must select a soil type that suits them. The soil should have some sub-surface moisture available in November and December.

Sub-soil moisture can usually be found in sites such as valley floors, downslope from granite outcrops or ironstone-mallet hills, or bordering on seepage areas.

The key to establishing perennials in areas with less than 700 mm rainfall is getting them well enough established to carry through the first summer drought. To do this:

- generally establish them early in autumn (in coastal and summer-rainfall areas, August sowings are preferred), and
- control weeds, which will either compete with the young seedlings or use precious water that should be stored for the perennials to use in summer.

Early preparation

If sowing grasses, use lupins or the pasture phase of a rotation to clean up grass weeds the year before sowing the pasture. You need to plan at least a year ahead.

If sowing lucerne, crop with a cereal the year before sowing with an emphasis on getting excellent broad-leaved weed control. Weeds that must be controlled are: sorrel, melons, wireweed, mintweed and dock. They are extremely hard to control in lucerne and use water during the critical summer period.

Preparing the seedbed

Where cultivation is needed, give a one pass working in the dry if possible, leaving a rough cloddy surface to minimize the erosion risk. Work down into a fine firm seed bed with the first autumn rains. The seed bed must be fine - remember you are sowing small seeds not cereal or lupin.

If your seed bed becomes light and fluffy (like powder to walk on), it will need rolling with a light roller to get a good pasture establishment. Generally, roll after the seed is broadcast. However, rolling before drilling the seed may be used to good effect, as it evens the surface, reduces irregular sinking of tyres into the ground and therefore gives more accurate seed placement.

Take care - rolling and wind erosion go hand in hand.

After cropping on sandy-surfaced soils, direct seed after controlling weeds chemically.

Early weed control

Spray out the first germination of weeds and sow as soon after the break as possible. Give your perennial pasture paddocks priority over crop. They are not going to be one year wonders - you will live with the result for quite a few years.

Sowing rates

Sowing rates will depend on species and rainfall. For example, lucerne should be sown at about 2 kg/ha below 400 mm average annual rainfall, at about 4 kg for 400 to 600 mm and 6 kg for 600 to 750 mm rainfall. At 2 kg, expect only one to four lucerne plants per square metre.

Don't expect to achieve a dense stand as with irrigated perennials when you only have a 400 mm rainfall. The stand will be basically annuals, supplemented with about 20 per cent perennials, at the lowest sowing rates. Denser sowings can lead to weak plants and sometimes early death of the stand as the perennials compete with each other for a very limited summer water supply.

Inoculate legumes

All legume seeds should be inoculated and lime pelleted not more than three weeks before sowing.

Protection crops

Lucerne can be sown with protection crops of cereal rye, barley or oats, sown at 10 kg/ha, if the lucerne is likely to be 'sand blasted' in windy areas. The cereals should be grazed to a 7 to 10 cm stubble by the middle of August and any regrowth of the cereal totally grazed out by the end of September.

Department of Agriculture trials with lucerne, sown in spring on the south coast, show that cover crops taken through to the grain stage do not help lucerne establishment on old land. Where a cultivation in June has been necessary, sow a cereal crop to reduce the chance of wind erosion, but spray it out before the paddock is sown with lucerne.

If the crop is allowed to develop to the tillering stage and then sprayed with a 'knock-down' herbicide, it will provide enough dead plant material to guard against wind erosion.

Sowing methods

Sowing method will depend on your skills, implements and species to be sown. The smaller seeded varieties, such as strawberry clover and puccinellia, are best broadcast and lightly rolled, if wind erosion is not a hazard. Larger seeded varieties like lucerne and tall wheat grass are best sown at 1 cm depth if you can do it.

Pull out the dropper line from your air seeder and run the seed on to the surface of the tine groove. Follow this by your spring-tined harrows set at 2 to 4 cm depth and running in this groove. This will generally place most pasture seeds at about 1 cm. Don't worry if as much as one-third of the seed is still on the surface.

Lucerne can be sown with a disc drill of a combine using narrow lucerne points on the seeding tines only, after removing the cultivating tines.

Fertilizers

Which fertilizers to use depends on soil type and previous cropping and fertilizing. Generally, use at least 100 kg/ha superphosphate, broadcast with the appropriate trace elements at establishment. For lucerne and legumes, a spring topdressing of potash in the second year may be needed on sandy soils. Consult your local Department of Agriculture adviser or fertilizer representative.

Grasses will respond to dressings of 75 kg/ha of urea in June and again in early August, particularly if they do not follow a legume crop. Take care: nitrogen can encourage undesirable grass weeds if they are present.

Pest control

Control insects as a matter of course a week to ten days following sowing into moist soil. An insecticide with some soil activity will help. Imidan® and Lemat® have been successfully used as seed dressings on grass seeds in other States; only Lemat is registered as a seed dressing in Western Australia.

Contact the Department of Agriculture if weeds emerge in the newly sown stand, as soon as you see them.

Grazing management

Only graze to control weeds in the first year. Heavy winter grazing may be needed to keep annual weeds down, since the perennials are slower growing than annuals then.

Graze laxly in early spring, then let the plants go rank and put down deep roots. Do not graze the perennial grasses over the first summer. If lucerne is starting to shed leaves from droughting, graze the stand hard and quickly.

Graze perennial grasses heavily in the following autumn. They will withstand heavy grazing pressures, provided they are given a month to six weeks to recover between grazings.

The aim in the first two years of a perennial stand is to develop crowns of 10 to 15 cm diameter. This provides some protection for the growing points in future grazing. Crown development is best achieved by occasional light grazing. Ryegrass is the only perennial that may not need this crown development.

Drought tolerance

The order of drought tolerance, from least to most tolerant, is: perennial ryegrass, tall fescue, kikuyu, cocksfoot, phalaris, perennial veldt grass, tall wheatgrass, lucerne. This is a general guide; there is significant variation in drought tolerance between varieties within each species.

Further reading

- Farmnote No. 67/86 'Redlegged earth mite and lucerne flea in Western Australia' (Agdex 622).
- Farmnote No. 6/87 'Techniques for inoculation and lime pelleting' (Agdex 100/23).
- Farmnote No. 3/88 'Webworms in crops and pasture' (Agdex 100/622).
- Farmnote No. 4/88 'Cutworms - pests of crops and pastures' (Agdex 100/622).
- Farmnote No. 91/88 'Growing lucerne on the south-east coast' (Agdex 121/20).

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Farmnote
No 91/88

Western Australian Department of Agriculture

Agdex 121/20
Lucerne/culture

Growing lucerne on the south-east coast

By John Richardson, Adviser, Esperance

Lucerne is easy to establish on new land on the south-east coast of Western Australia. However, re-seeding the new aphid resistant lucerne varieties into old pastures can be difficult because of the increased pressure from weeds and root diseases.

The sandy soils on the south-east coast are also often water repellent. Water penetration is poor, which causes erratic germination of the lucerne seeds. These factors have led to the failure of many reseeding efforts, but by using the right approach to lucerne establishment, the probability of failure can be reduced and a successful stand established.

Soil types

Lucerne grows best in well drained soil. Deep sands or sandy gravels are also preferred. Avoid sandplain soils with a dense or compacted lateritic layer ('coffee rock') which restricts the depth of root growth.

Lucerne is often suited to soil types that fail to support good subterranean clover stands. With the right management, lucerne can support as many sheep as a good subterranean clover stand.

Varieties

For information on which lucerne varieties to plant see Farmnote No. 26/88 'Dryland lucerne varieties for the south-east coast of Western Australia' (Agdex 122/32).

Planting time

Lucerne seedlings are poor competitors for water and nutrients, so seed must be planted at a time that favours lucerne growth rather than weed growth.

The best time to plant lucerne is in August, when the soil is wet and the chances of follow-up rains after seeding are good. From August the average daily temperature increases, which favours lucerne growth. If possible, choose the planting time to coincide with the passage of low pressure fronts through the area.

If lucerne is planted in the middle of winter, seedling growth will be too slow to compete with the winter weeds. If it is planted too late, summer weeds will compete with the seedlings.

Inoculation

Lucerne seedlings may be slow to nodulate, so inoculate the seed with Group A inoculum as close to the day of seeding as possible. Lime pellet the seed if trace element fertilizer is used as a 'carrier' [see Farmnote No. 5/87, 'Inoculation and lime pelleting of medic seed' (Agdex 137/23)].

There is no local evidence to support the theory that liming the paddock before seeding will improve lucerne seedling establishment.

Weed control before seeding

Avoid planting lucerne into paddocks with large areas of sorrel, dock or wire-weed. If these weeds are a problem, plant a crop into the paddock the season before planting lucerne and treat the weed in the crop. Cropping a paddock can leave it more prone to wind erosion the following year if the stubble is grazed too hard over the summer.

Paddocks that were extremely grassy in the year before planting lucerne may also be a problem because the grass may germinate after lucerne is planted. This weed pressure can be reduced by 'spray-topping' the season before planting lucerne.

Fallow period

Results of trials in South Australia show that a fallow period before seeding reduces the incidence of some root diseases in crops. Trials in Western Australia show that lucerne establishment is best when planted after a chemical fallow period. A split application of Roundup®CT or Spray.Seed 200®or both is suggested for chemical fallow. The longer the fallow, the better. About five to six weeks of fallow is suggested.

Weeds can be controlled easily during a fallow period. However, if there was a large amount of grass in the paddock the year before and the lucerne is direct-drilled with a combine (using cultivating points), then the cultivation may stimulate a fresh germination of grasses despite the long fallow. These grasses would then have to be sprayed with a selective herbicide, such as Fusilade®or Sertin®. Using a disc drill or narrow lucerne points to seed lucerne avoids this problem.

Cover crops

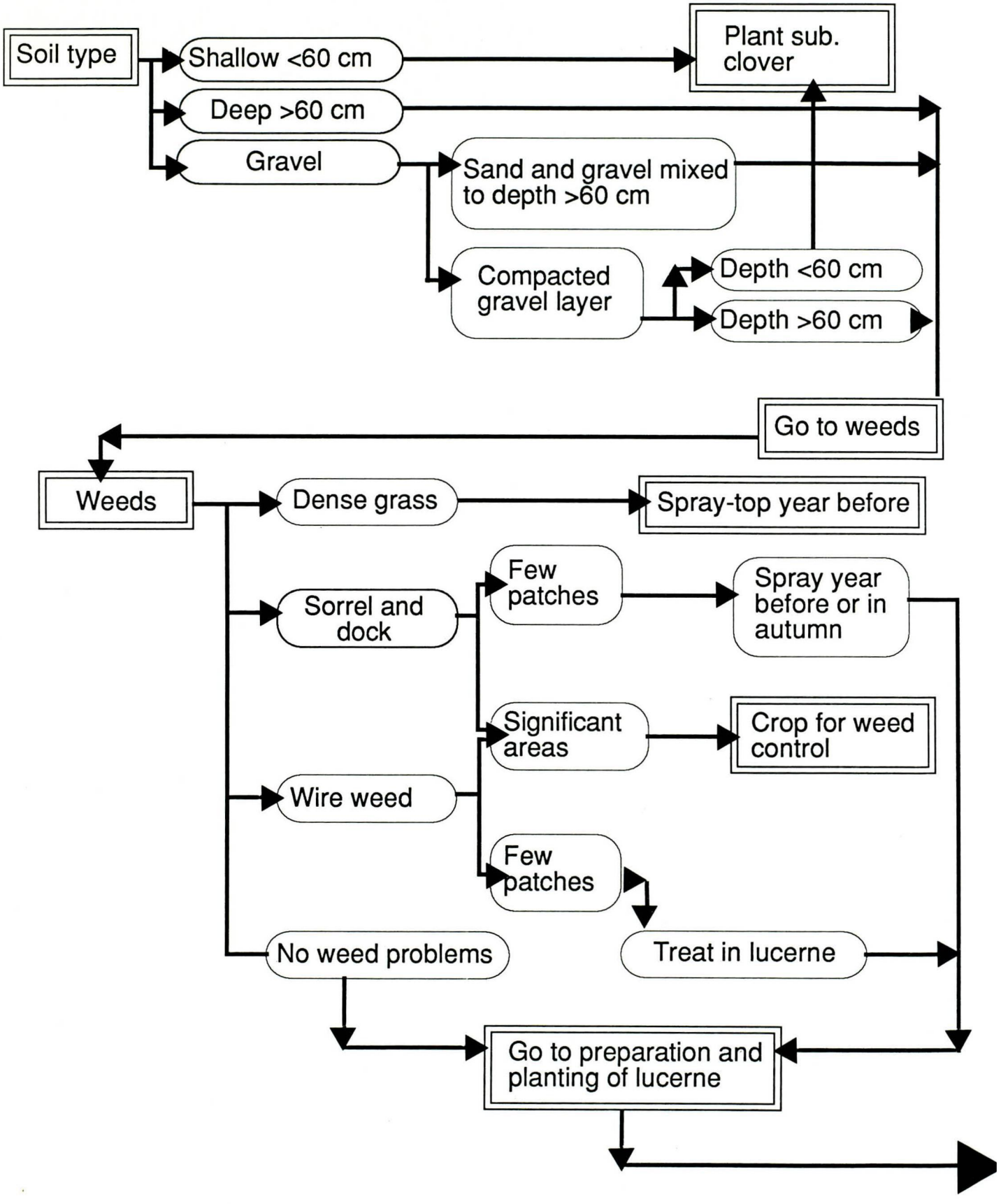
Cereal cover crops have been used to protect the soil from wind erosion and to provide extra feed when establishing lucerne. However, results of Department of Agriculture trials show that cover crops on old land situations do not help lucerne establishment. They tend to act like weeds and compete for moisture at the end of spring. This can reduce the density of the lucerne, or at worst, result in failure of the lucerne crop to establish.

There may be some situations where the paddock is cultivated before lucerne is planted. To reduce the chance of wind erosion, a cereal crop may be sown, but it must be sprayed before the paddock is sown with lucerne.

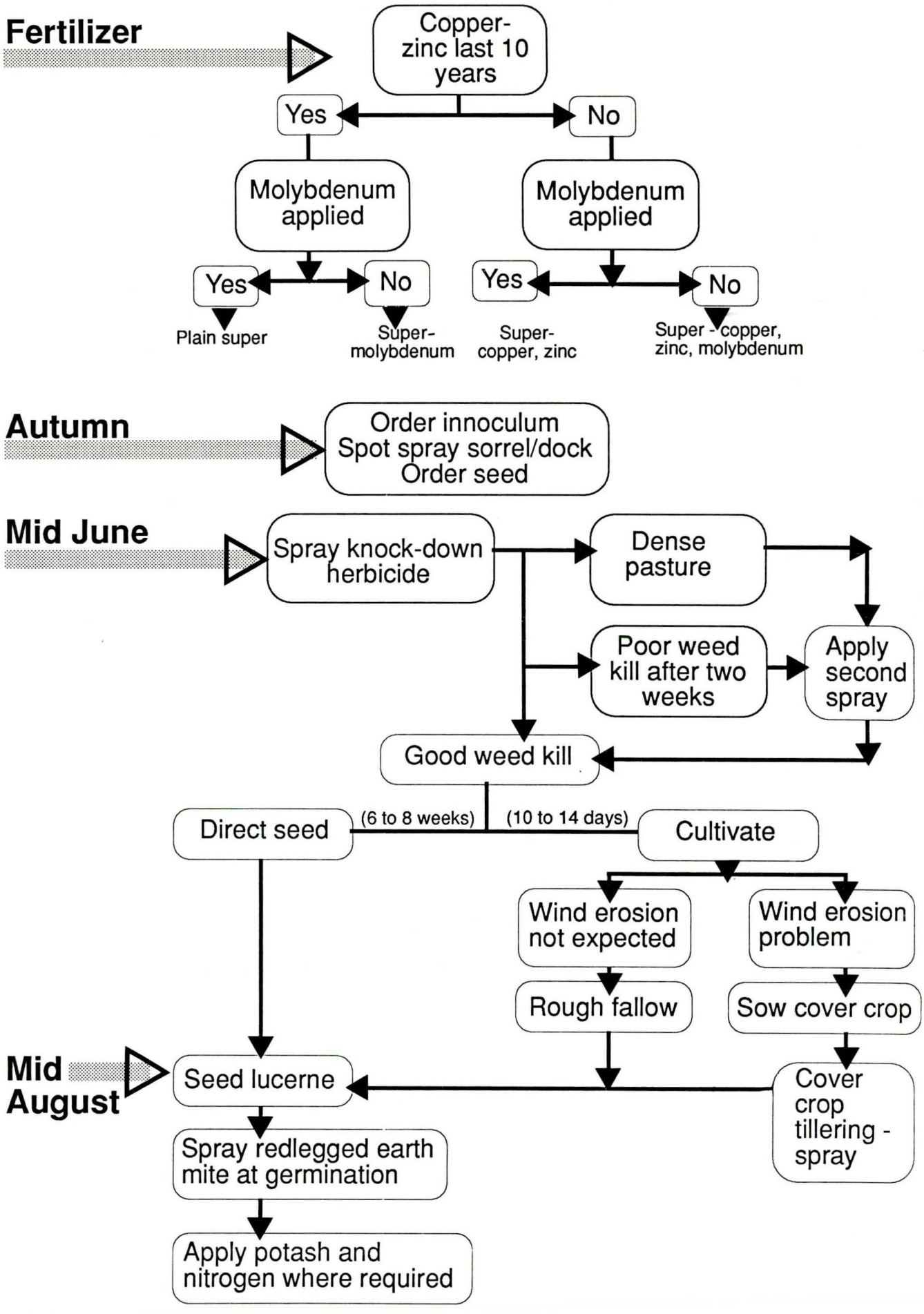
If the crop is allowed to develop to the tillering stage and then sprayed with a 'knock-down' herbicide, it will provide enough dead plant material to guard against wind erosion. The lucerne can be sown with a disc drill or a combine using narrow lucerne points (after removing the cultivating tynes) on the seeding tynes only.

Continued overleaf...

Decisions to be made the season before planting lucerne



Preparation and planting of lucerne



Seedling nutrition

Copper, zinc and molybdenum fertilizer should have been applied within the last six to 10 years to paddocks in which lucerne establishment is planned. Topdress or drill superphosphate with the seed in the year of sowing lucerne.

On the sandy ridges it may be necessary to topdress the seedlings after emergence with nitrogenous and potassium fertilizer. This is because leaching is greatest on these areas and the seedlings may struggle to survive without extra fertilizer.

Insect control

Insect control in the seedling lucerne is extremely important. The main problems are redlegged earth mite (highly likely), cutworm and blue-green aphid (less likely).

To control redlegged earth mite apply an insecticide such as chlorpyrifos, maldison or methidathion. These chemicals may be applied just before the lucerne seedlings emerge [see Farmnote No. 67/86, 'Redlegged earth mite and lucerne flea in Western Australia' (Agdex 622)].

Small cutworms will feed on the lucerne leaves, causing the appearance of 'windows'. When the grubs are bigger they are capable of lopping the seedlings off at ground level and must be controlled.

Blue-green aphids may feed on the growing point of the new lucerne seedlings. If their numbers are great enough they will affect the growth of the seedlings and will need to be controlled, using a systemic insecticide (such as dimethoate, omethoate or Pirimor®).

Early grazing management

Do not graze lucerne seedlings until about one-tenth of the seedlings are flowering. This ensures that the root system will be well established and that the plant has maximum root reserves for the production of new growth after grazing

There are two exceptions to this strategy:

- If there is a late germination of weeds, light grazing may reduce the competition from weeds.
- If the lucerne is moisture-stressed the leaves will drop, so sheep can graze this plant material before it falls to the ground.

In all cases, grazing must be controlled so there is no damage to the developing crown of the lucerne plant.

If conditions are favourable the lucerne can be cut for hay instead of grazed.

Future management of the stand

For future management of the lucerne stand, three factors to consider are:

- Fertilizer - an annual top-dressing of superphosphate at the rate used on subterranean clover pastures. Some stands of lucerne show signs of manganese deficiency, so superphosphate with manganese is also recommended at 100 to 140 kg/ha for three to four years instead of plain superphosphate.
- Grazing - if running sheep, graze the lucerne in rotation. The rest period between grazings should be about six weeks. This is important when lucerne is the main pasture material available to stock in summer, autumn and early winter. Grazing management with cattle is usually easier than with sheep.
- Weed control - in established lucerne stands weed control is aimed at those weeds which are a problem to grazing animals (such as brome grass, barley grass and geranium). These weeds can be controlled at seed set in spring using Gramoxone®, or by early winter manipulation with Spray.Seed 200®.

The diagrams in the centre outline the decisions to be made the season before seeding lucerne and the preparation needed in the year of seeding lucerne.

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LUCERNE ESTABLISHMENT - Ian Maling and Justin Hardy

Essential to control all weeds in the year preceding an autumn sowing

1. Fine, firm, weed free seed bed. (pH > 6.0)
   Allow germination and spray out with Roundup if sorrel present. (Do not use Ally in year of sowing).

2. Plant before cold sets in (comprise with 1 above)

3. Sow lime pelleted inoculated seed within one week of inoculation.

4. Sow with 200 kg/ha lime if possible.

5. Seed to be broadcast and rolled in.

6. Topdress with Super Cu Mo Zn 100 kg/ha.

7. Control insects maximum 2 weeks post sowing, and again 2-3 weeks later, and then as a matter of course (e.g. lucerne flea, redlegged earthmite).

8. Apply potash in spring - 100 kg/ha.

9. Contact the Department of Agriculture for winter control of weeds.

10. Cover crop:

    10 kg/ha of either - Cereal rye
    Barley
    Oats.

SERRADELLA ESTABLISHMENT - Gerry Parlevliet

There are areas of deep sand on most farms which do not grow much in the way of clover or crop. Soil tests usually show these soils to be low in potassium and phosphorus.

Serradella has been established in some areas successfully and is worth a try on your farm.

Seed is sold as pods and should be topdressed at 5-10 kg/ah. The seed is costly and germination is low, so the suggestion is to sow under a cover crop. One such crop is lupins. This could do well on deeper sands and if inoculated provides the rhizobium for the serradella.

Sow the cover crop then topdress the serradella - don't incorporate.

Under the cover crop (assuming the pods are not treated to improved germination) germination is about 5%. The following year germination will be about 60-65% as the hard seeds of serradella will be broken down under the crop.

Grazing of lupin stubble should be done early to avoid lupinosis and should be reduced around the break of the season to allow serradella to produce some bulk. Hard grazing during winter should be used to prevent grass out-competing the serradella. Reduce grazing at flowering to allow seed set. During the pasture year a potash application in spring will increase seed set.

The varieties suggested are Tauro, a mid season variety, Madeira, a short season variety and Pitman as a bulk variety to reduce cost.

If the area of serradella is a small area in a larger paddock then fence if off to control grazing.

Details on seed treatment are available for those interested.

ESTABLISHING TALL WHEAT GRASS - Carmen Saunders

1. Spraytop area to be sown in the previous spring to reduce grass seed set.

2. Cultivate after first rains to encourage weed germination and to produce a fine seed bed. If the site gets wet/boggy, a knockdown spray and direct drilling into the existing stubble may be a better option.

3. Spray out weeds.

4. Sow seed (earlier in Autumn the better) through a small seed box, dropping them onto the surface. Trail a set of light harrows turned over (tynes upwards) to provide a light cover - no more than 1 cm of soil. Do not worry if as much as 1/3 of the seed is on the surface (Sowing rate: 3-4 kg/ha, cost of seed approximately $3.50 - 1991).

   If a carrier is required, use superphosate rather than Agras as Agras is highly osmotic (attracts water) and absorbs all moisture from the germinating seed. Alternatively, seed can be broadcast then rolled with a 'tyre' roller or some other light roller (Caution: rolling and wind erosion go hand in hand).

5. Establish with 100 kg/ha superphosphate plus trace elements depending on fertiliser history. Topdress with 2 applications of urea, 75 kg/ha in June and early August.

6. Spray for redlegged earthmite 10 to 14 days after sowing and whenever necessary thereafter.

7. In the first year graze only to control weeds. Grace laxely in spring to let plants go rank and put down deep roots. Do <u>not</u> graze over first summer.

8. Graze heavily following autumn and thereafter when feed is available - however do not overgraze causing damage to crowns. A month to six weeks is usually required to recover between grazings.

9. Tall wheat grass can be successfully sown in a mixture with any suitable legume.
   e.g.: 3 kg/ha TWG + 2 kg/ha puccinellia + 1 kg/ha balansa clover (wet sites).

Note: Tall Wheat Grass is not very impressive as a seedling nor in its first year of sowing. But with patience and careful grazing management it will develop into a productive pasture.

PHALARIS ESTABLISHMENT - Justin Hardy and Ian Maling

Phalaris is a deep-rooted perennial for areas with mild, moist winters and hot, dry summers. It will withstand both dry and waterlogged conditions and persists under heavy grazing.

Phalaris makes best growth in autumn and spring and good growth in winter. It becomes dormant in summer after it sets seed.

Phalaris seedlings are small, slow to establish and sensitive to competition for light, so sowing ryegrass with Phalaris is not recommended. It does combine well with subterranean clover, medics and lucerne.

It is best to sow Phalaris alone in late winter or early spring, broadcasting the legume seeds with superphosphate the following autumn when the Phalaris pasture is well established. Good establishment of Phalaris has also been achieved by using herbicides to reduce clover and weed competition before sod-seeding, drilling or broadcasting Phalaris into a clover dominant pasture. Sowing rate is usually 2-4 kg/ha but can be up to 6 kg/ha.

The 'Sirolan' cultivar of Phalaris is recommended for this area.

Caution: 'Phalaris staggers' causing sheep deaths, can occur when hungry sheep are put on phalaris pastures.

Best Bet Procedure:

1. Spraytop grasses the previous spring to reduce seed set.

2. Cultivate after the first rains to encourage weed germination and produce a fine seed bed (remember we are sowing a small pasture grass not a large grain).

3. Spray out weeds.

4. (a) Broadcast seed and lightly pasture harrow before rolling with a "tyre" roller or some other light roller (2-4 kg seed/ha). Note: this harrowing will lead to more weed seeds germinating.
   or
   (b) If you are used to sowing pasture grasses and can place the seed at a maximum of 1 cm depth then drill in the seed with a lucerne point or some chisel point which causes minimal soil disturbance (1-3 kg seed/ha).
   Note: Treat the phalaris seed with Imidan or Lemat prior to sowing (if affordable).

5. Control broad leaved weeds post sowing with one of the hormone sprays or Ally depending on species. (Note: Do not use Ally if sowing lucerne as well)

6. Topdress with 75 kg/ha of urea 2-4 weeks post sowing.

7. Topdress with 75 kg/ha of urea approximately every 10 weeks thereafter till the end of October.

8. Spray to control insects 2-3 weeks post sowing as a matter of course and whenever necessary thereafter.

9. Graze laxely in spring - let plants go rank and put down deep roots.

10. Graze heavily the following autumn and topdress on appropriate legume seed mixture - lightly harrow if desired. However avoid damaging phalaris crowns and provoking a weed problem.

Farmnote
No. 61/90
Faces 82/84

Western Australian Department of Agriculture

Agdex 137/10
Pasture legumes/management

Balansa clover

By Laurie Cransberg, Research Officer, Albany

Paradana balansa clover has a variety of leaf markings

Excellent spring growth of Paradana balansa clover

Balansa clover (*Trifolium balansae*) is an annual legume from Turkey, selected in 1973 from a range of clover species by the South Australian Department of Agriculture for its resistance to clover scorch disease. Trials on Kangaroo Island and in south-east South Australia led to its recommendation and registration under the name Paradana in 1984.

Trials in Western Australia started at Esperance in 1980, after clover scorch severely affected pastures during the 1970s. Interest spread to the south west region in 1985 with large scale sowings, and has been maintained.

Species description

Balansa clover is an erect, hollow-stemmed herb with leaflets having a distinctive serrated edge. The leaf markings of Paradana are variable, ranging from distinct white, grey or pink crescents with or without a white apex to no markings (about 60 per cent of leaves).

The flower heads are large and contain many flowers, each on a separate stem, which produce two to four seeds. The flowers are long and white, terminating in a pink tip. The seeds are yellow, brown or black and are very small (1.4 million/kg).

Agronomic characters

Balansa clover is capable of very rapid growth in warm, moist conditions. In an early break season, a regenerating stand will be faster growing than a subterranean clover stand, and in spring production is again higher than subterranean clover based pasture. However, during the colder months the dry matter production of Paradana is less than that of Trikkala.

It has the capacity to withstand wet, waterlogged conditions during winter, though it will not tolerate extended periods under water.

Balansa clover flowers in early September on the south coast for up to eight weeks, depending on soil moisture. Under conditions of spring moisture stress, it has the capacity for rapid seed development, ensuring adequate seed for subsequent regeneration.

Balansa clover is generally tolerant of clover scorch disease, though several cases of restricted damage have been confirmed.

The seed produced contains high levels of hardseededness, up to 80 per cent, which is an important asset on the south coast of Western Australia, where false breaks are common.

Seed establishes readily after passing through stock. South Australian work has shown that between 30 and 40 per cent of seed eaten passes through stock and remains viable - compare this with 2 to 5 per cent for subterranean clover.

Balansa is capable of high seed production, with yields around 750 kg/ha being recorded in a large scale grazing trial at Manypeaks.

Suitable areas

Balansa clover is best suited to areas currently supporting subterranean clover. These are generally the shallow duplex sandy soils, gravels and loams lying over a heavier subsoil, with pH ranges from 5.3 to 7.0. Poor results have been reported on deep acidic sands (pH 4 to 5), and on poorly drained alkaline clays. In Victoria, it has also been successful on salt-

affected, low lying, inundated areas close to the coast. Rainfall zones greater than 425 mm offer the best prospect for productive stands.

Establishment

Good weed control before sowing is essential. Being small seeded, balansa clover is a very poor competitor early; the tiny seedlings can be easily shaded. Ideally, seed should be dropped on to a finely prepared seedbed and just covered with light harrows. Pure stands should be sown at 2 to 3 kg/ha, while in a mix 1 kg/ha is recommended.

Seed must be inoculated with either Group C or Group B inoculant, unless it is being sown into old subterranean clover land. Techniques for inoculation are described in Farmnote No. 6/87 'Techniques for inoculation and lime pelleting' (Agdex 106/23).

Balansa clover is extremely susceptible to red-legged earth mite in the cotyledon stage. An insecticide application is strongly recommended, either by treating seed if no inoculation is needed or by applying insecticide shortly after emergence if the seed is inoculated.

Management

Winter

Balansa clover needs grazing during winter, like other legumes, to control faster growing species such as capeweed, grasses, dock and geranium. Lax winter grazing will cause shading and emphasize its lack of competitiveness at this time of the year.

Grasses can be readily controlled if necessary, using a range of herbicides registered for grass control in legume crops. Control of broadleaved weeds is best achieved by using stock; there are no chemicals registered for their control in balansa clover.

Spring

To optimise seed production, either for harvesting or as a seed bank for subsequent pastures, stock should be removed at the start of flowering. They should not be returned until the seed has matured.

Once a seed bank has been established, complete removal of stock in spring is not essential unless seed is to be harvested, but an easing of grazing pressure is advisable.

Current research suggests that heavy red-legged earth mite infestations in spring will markedly reduce seed production. Therefore, further insecticide application may be necessary.

Cutting balansa clover for hay in spring will yield good quality hay that can be baled without excessive leaf loss. Digestibility and crude protein levels of balansa clover hay are similar to those of subterranean clover hay. Balansa clover appears suited to hay production, since it can provide grazing until early September and then produce spectacular spring growth. However, under a hay production system, little seed will be set and continuing regeneration cannot be expected.

Summer and autumn

Hard grazing of dry balansa clover residues is important. Ideally, very little residue should remain at the break of the next season. Trial work has shown that balansa clover regenerates very poorly when there is much dry pasture left in autumn, even after high seed set the previous year. Hard grazed summer pastures, in contrast to this, have shown excellent germination.

Dry balansa clover residues are more digestible than subterranean clover residues, though protein decline of balansa clover is slightly quicker following summer rains.

Fertilizer

Balansa clover is very responsive to fertilizer. The highest productivity and seed yields have been seen on farms where relatively high levels of fertiliser have been applied. This usually comprises an autumn application of superphosphate followed by a dressing of potash at the start of flowering. Use a soil test to determine the rates to use.

Seed harvesting

Harvesting seed does not require specialised equipment. A conventional open-front crop header with closely spaced combs is suitable. The flowers must be harvested before seed shedding starts. Keep a close watch on the stand as the season dries off, to ensure maximal recovery.

Vacuum or clover seed harvesters can also be used but the small seed cannot be readily separated from sand on-farm, and this harvesting method may create an unstable soil surface, susceptible to wind erosion.

Future scope

Balansa clover still requires research input to define its optimal use in farming systems. It has been shown by a limited number of farmers to be exceptionally productive over the long term in set-stocked pastures. In most instances, balansa clover pastures tend to be more readily invaded by other species than are subterranean clover pastures.

Currently, balansa clover appears best suited to hay production, usually in a mix with a grass. However, it is also recommended as a component of resown pasture mixes, because of its low cost (only 1 kg/ha is needed in a mix) and potential benefit in the shorter term.

Further reading

•Farmnote No. 6/87 'Techniques for inoculation and lime pelleting' (Agdex 100/23).

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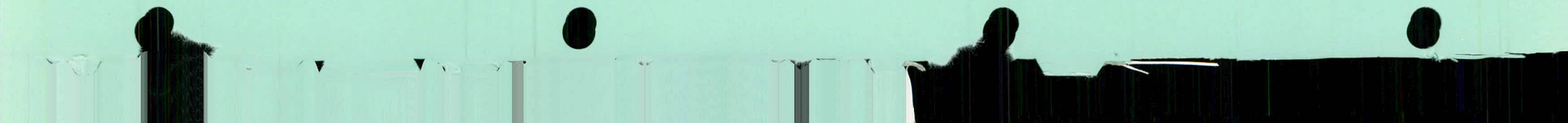

Agdex 723/75
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Western Australian
Department of Agriculture

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Bulletin

ELECTRIC FENCING

Versatility
Farmers throughout Australia are changing to electric fencing because of its versatility. Properly constructed electric fences will control ALL domestic animals and vermin such as kangaroos, emus, dogs, wild pigs, rabbits and wallabies. In most cases, a fence capable of controlling a range of domestic and vermin animals can be built for a cost similar to or lower than that of a conventional sheep or cattle fence.

Electric fencing is being used in soil conservation programmes. Fencing on the contour and along creek lines is now practical, because the number and size of strainer assemblies is much lower than for a conventional fence.

Electric fencing has enabled Australian farmers to undertake extensive tree planting programmes. Protecting large numbers of trees with conventional fences is too costly.

Cost advantages
The major aspect attracting farmers to electric fencing is its reduced cost. A four wire sheep electric fence can be built for approximately one half the cost of a conventional sheep fence. With the current farm cost/price squeeze, all farmers must now consider electric fencing when planning future fencing programmes. (Table 1)

HOW IT WORKS

An electric fence energiser produces a pulse of electricity every second. This pulse is transmitted along all 'live' fence wires. When an animal touches an electrified wire, the electricity flows through the animal and back to the earth terminal of the energiser, either through the moist soil (ground return system) or through an earth wire in the fence (fence return system). This gives the animal an unpleasant but harmless shock.

'Ground return' system
In regions where the ground remains moist all year (irrigation area), electricity can travel through the ground from the fence to the earthing system at the energiser. As all wires in the fence can be electrified, the number of wires required to control domestic stock can be reduced.

Fence return systems
Most of Western Australia experiences dry summers, so consequently will not support a 'ground return' electric fence system. Under dry conditions, an electric fence must contain both electrified and earth wires. The earth wires are connected to the earth terminal of

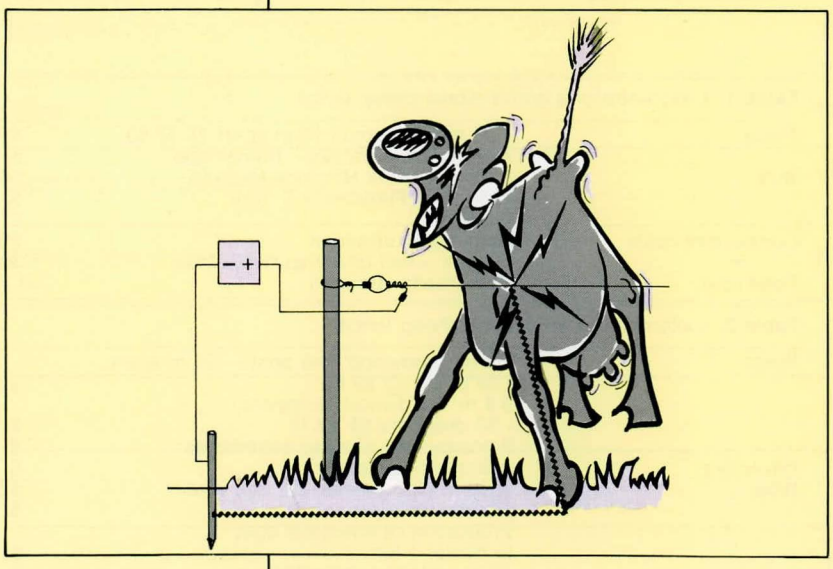


Figure 1: Ground return circuit. Requires moist soil for good conductivity to complete circuit.

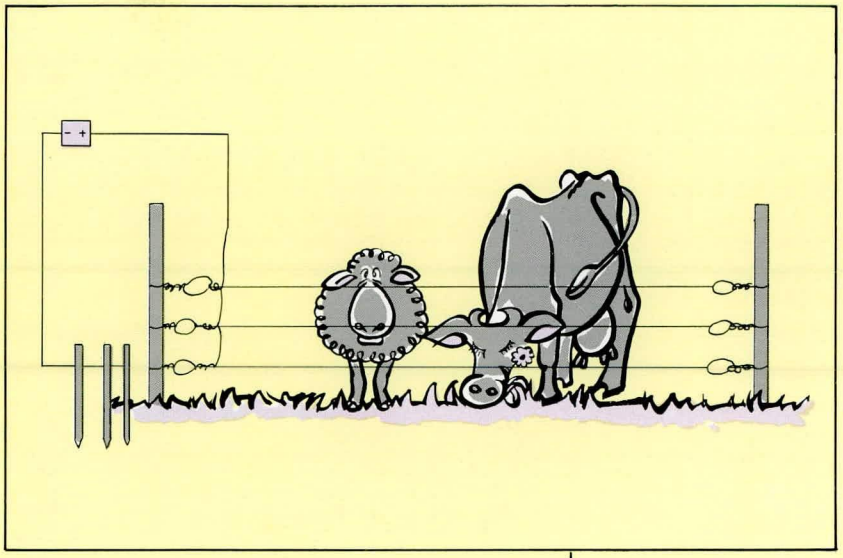


Figure 2: Permanent moist country design for sheep and cattle.

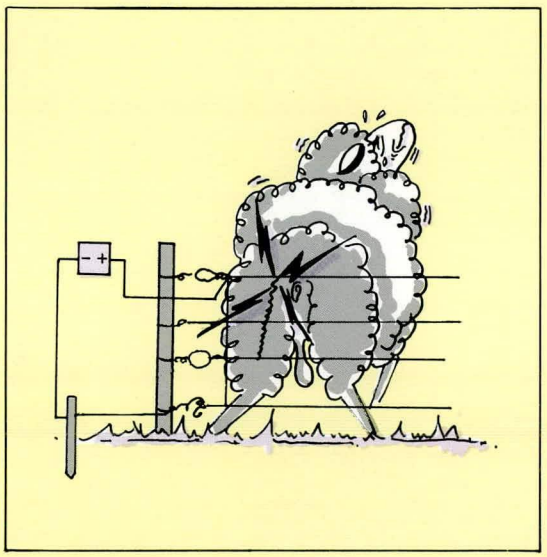
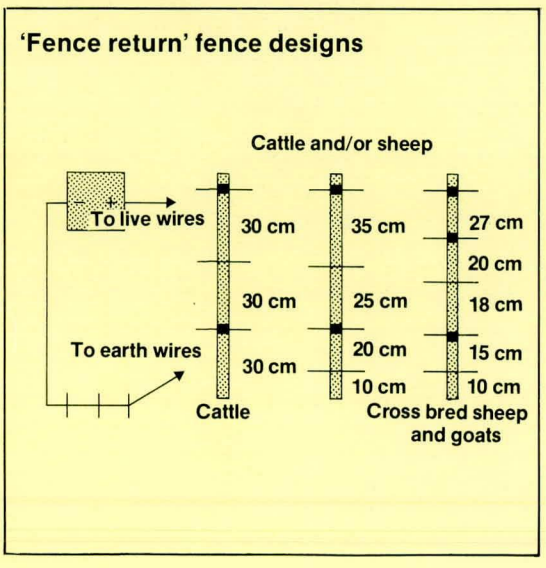
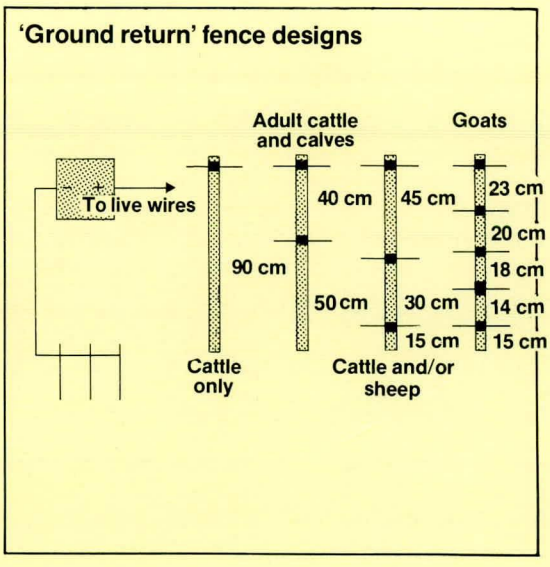


Figure 3: 'Dry country' fence design.





the energiser via the earthing system. When an animal touches both the live and earth wires, it completes an electric circuit and receives an electric shock (see figure 3).

ELECTRIC FENCES FOR DOMESTIC ANIMALS

Many designs of electric fences are available. A fence should be designed according to the soil conditions and the type of animal to be controlled.

The coats of all animals are reasonable insulators and can reduce the effect of the electric shock produced by the fence. However, the insulation effect of the coat is minimised by the manner in which the animal approaches a fence. For example, cattle usually walk up to a fence and first test it with their moist noses and receive a large shock. They are relatively easy to control with an electric fence.

Sheep

Sheep may approach a fence and try to push through it, in preference to first testing it. The fence wires must be positioned so that when a sheep begins to push through a fence, it comes in contact with the live and earth wires (under dry soil conditions) and receives a large shock.

Because wool is a good insulator, it can reduce the size of the electric shock a sheep receives. Ideally, sheep should be trained to electric fences soon after shearing, when the insulation effect of the fleece will be at a minimum. In practice this rarely occurs. Most often, untrained sheep are placed in paddocks with electric fences and consequently a small percentage of the sheep may penetrate the fence. Experience indicates that penetration of the fence will cease within one or two days. Most animals never forget the experience of an electric shock and soon learn to respect the fence. Many sheep learn from the experiences of others and become trained without receiving an electric shock.

If fences are suitably designed, they will control sheep well.

Other domestic animals

Electric fences will control goats, pigs and horses.

A simple outrigger for an electrified wire.

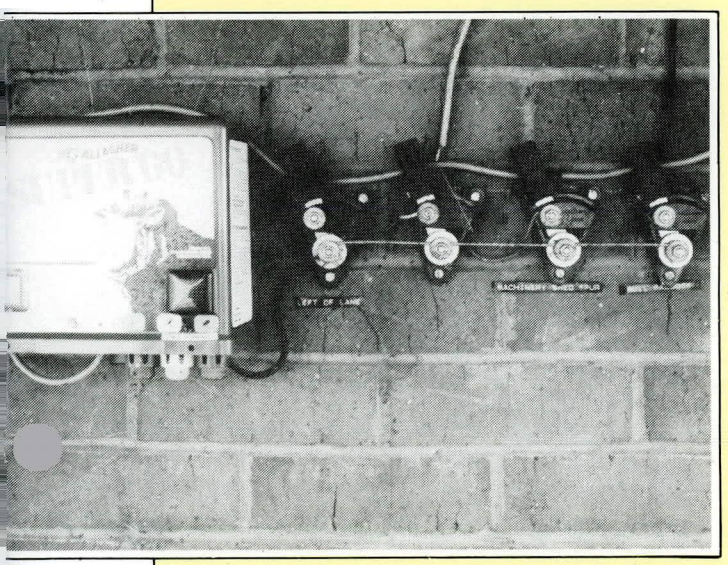
ELECTRIC FENCE DESIGNS

To update an existing fence

- *"Outrigger" design:* The life of an existing conventional fence may be extended many years by adding an electrified wire to it. The live wire is attached to an "outrigger" which supports the wire approximately 25 cm from the fence. This design is most suitable when the ground is moist, as it relies on the current being able to travel through the ground to the earth stake, to complete the electrical circuit. During the dry summers experienced in this State, current will not move through the soil efficiently and only a minimal shock will be produced. In this situation, the conventional fence should be connected to the earthing system. When an animal touches both the electrified wire and the conventional fence, a circuit is completed and a large shock received.
- *Conductive post design:* Where an existing fence has been built with dry split jarrah, wandoo, jam or mallet posts, wires within the fence can be electrified provided the energiser has a high power output.

To do this, insulate the wires at the strainer posts and ensure that any wire that is not connected to the live terminal of the energiser, is connected to the earth system, or it will become a neutral wire. Neutral wires may become charged by the magnetic field created by the electrified wire. This can lead to a number of problems, one of which is straying of the current to other fences or properties.

This method of electrifying an existing fence is cheap and prolongs the life of the fence may years. As some leakage of current may occur under wet conditions this method of electrifying an existing fence should be monitored using a voltage meter.



A modern mains-powered energiser unit with isolating switches for primary circuits.

ENERGISERS

An energiser is the heart of an electric fence system. The choice of a suitable energiser is of utmost importance if the fence system is to be fully effective and reliable.

Modern energisers are produced according to Australian Design Standards which limit the maximum voltage output to 10,000 volts and the maximum output energy to 8 joules, measured at 500 ohms resistance. No two electric pulses can be produced by an energiser at intervals of less than 0.75 seconds, and no pulse shall have a maximum duration greater than 0.05 seconds. These specifications ensure that all energisers are safe to humans and all other animals.

Energisers are available in many models and vary in both their source of power and power output. They may be powered by mains electricity, batteries or by solar panels. The choice of power source will depend on the availability of mains electricity, the location of the energiser and its cost.

- *Mains powered*
  Whenever mains powered electricity is available, it should be used. Mains powered energisers are powerful, reliable and are relatively cheap to purchase and operate. They are the most suitable energisers for long distance, permanent electric fencing.
- *Battery powered*
  Where mains power electricity is not available, battery operated energisers are a good alternative.

  The power output of battery operated energisers must be balanced against the life of the battery which powers them. There are two basic types of battery powered energisers — wet cell and dry cell units.

  24 to 32 volt wet cell powered energisers have a similar output to that of mains-powered energisers, and are suitable for the same long fences. The battery's life is limited, so a lighting plant generator should be run for at least half an hour per day to recharge, and maintain efficient energiser operation.

  The 12 volt, wet cell powered energisers have one quarter to one half the output of the mains powered energisers. However they will adequately power up to 20 kilometres of multiwire fence and are suitable for controlling all domestic animals. A car battery would need charging after four to six weeks and a heavy duty tractor battery would last up to ten weeks.

Six volt dry cell powered energisers are only suitable for short distances of temporary fencing. The dry cell batteries have a short life, are not rechargeable and are expensive.

- *Solar powered*

  Batteries powering energisers can be connected to solar panels and thus be recharged by the sun.

A solar panel is the most expensive source of power for an energiser. However, these can be useful on properties that are not visited frequently, or for electrifying fences in isolated areas of the farm, such as salt patches and clusters of trees.

Solar powered energisers capable of electrifying 2 km to 30 km of fence are available, either as complete units, or in kit form.

Energiser selection

When selecting an energiser, choose one that will handle your future fencing requirements. If you select a low-powered energiser to service your immediate fencing requirements you may have to buy another, more powerful energiser as your future fencing programme expands.

Take care when reading manufacturers' fence distance claims. Energiser distance performance is expressed under ideal conditions. Unfortunately these rarely occur. The estimated length of fencing an energiser is capable of electrifying depends on:

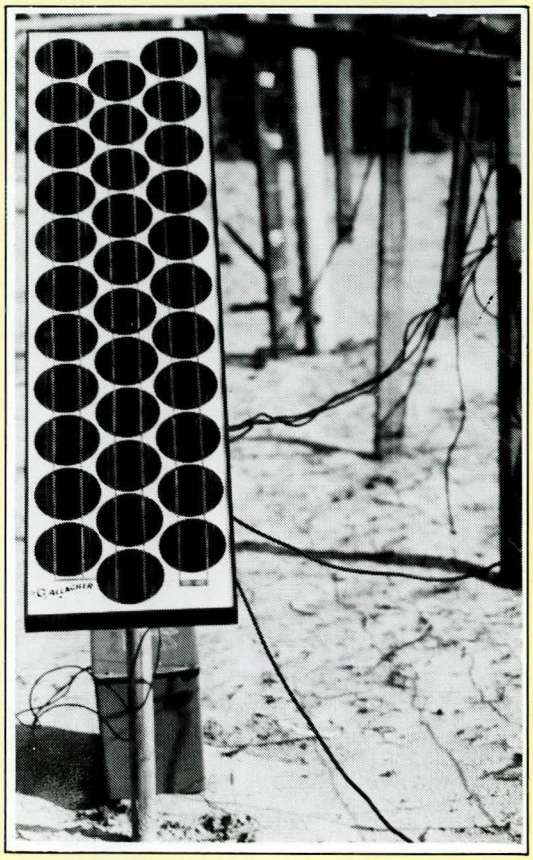
- climate,
- vegetation and growth type,
- fence construction,
- number and size of wires used,
- promixity of lower live wires to vegetation,
- the efficiency of the earthing system,
- the standard of insulation,
- the quality of wire joins,
- the type of stock to be controlled, and
- the energy output of the energiser.

All modern energisers are now fully modular and solid state construction. This makes for reliability and for easy servicing. Farmers can carry spare 'plug in' modules and change them in minutes.

Siting an energiser

Modern energisers produce a loud characteristic "ticking" sound which corresponds to each electric pulse. If the fence system is losing current, perhaps because of a 'short' occurring, the loudness of the ticking will be reduced. The quieter ticking is a good indicator that something is wrong with the fence.

You can take advantage of this warning system if, wherever possible, you site the energiser in a protected position that is visited frequently. The machinery shed or dairy are ideal locations. If a farmer notices that the ticking sound has diminished, with the aid of a voltmeter, he can start to locate the fence fault.



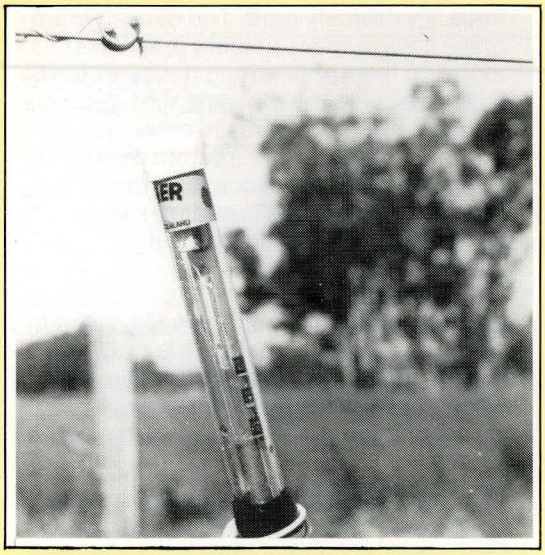
A solar panel re-charging energiser batteries.

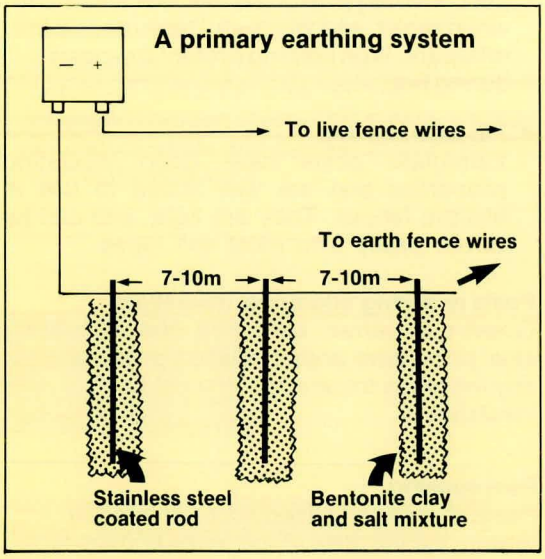
A flashing light, connected to the 'live' wires of a fence, is another quick way to monitor the pulsing. If the fence charge is more than 3000 volts, the light will flash with every pulse. If the fence charge is between 1000 and 3000 volts, the light flashes with every second pulse. Below 1000 volts the light will not flash at all.

A number of energisers now have their own built-in flashing light monitoring systems.

EARTHING

A flashing light used as an indicator of effective pulsing.





The earthing system of an electric fence is extremely important for maximum efficiency, particularly through the dry months. Unless a high standard earthing system is established, current flow from the fence will be poor and consequently the intensity of the shock an animal receives will be reduced. Poor earthing systems can also result in the 'straying' of current around the farm or even to neighbouring properties.

Many Western Australian soil types are not conducive to a good earthing system. Clays and clay loams are the best soil types for earthing, followed by gravels, sands and rocks. The sands and gravels, as well as having a high electrical resistance, or poor earthing properties, may be acid. This causes corrosion of the earthing electrode, resulting in reduced efficiency.

For most soil types in Western Australia, stainless steel is the most suitable earthing material. It will not corode, and will remain efficient for many years. As stainless steel is expensive, iron rods, coated with stainless steel are used in the acid soil types.

A primary earthing system should be established by connecting the earth terminal of the energiser to two or three earth stakes which are placed in the ground, 7 to 10 metres apart. To improve the contact between the stainless steel coated earthing rods and the dry soils, the rods can be placed in a metre-deep core of a 2:1 bentonite clay and salt mixture. Bentonite clay is a high expanding substance which ensures complete contact with the earth rods. Butchers' salt is added to improve the soil conductivity immediately surrounding the earth rod. About 100 mm of sand could be placed over the mixture to help prevent moisture loss by evaporation. The one-off cost of a good quality primary earthing system is approximately $80.

The primary earthing system must be placed at least 10 metres from any other earth or electrode. It must be well away from S.E.C. or Telecom earth rods because any fault in power supply could affect the fence or vice versa.

Additional or secondary earth rods should be added to the earth system as the fence distance increases. They should be well distributed around the farm, but not necessarily at regular positions along the fence. Good earthing sites such as salty ground, creeks, rivers, dams or seepage areas should be used wherever possible.

The earth wires

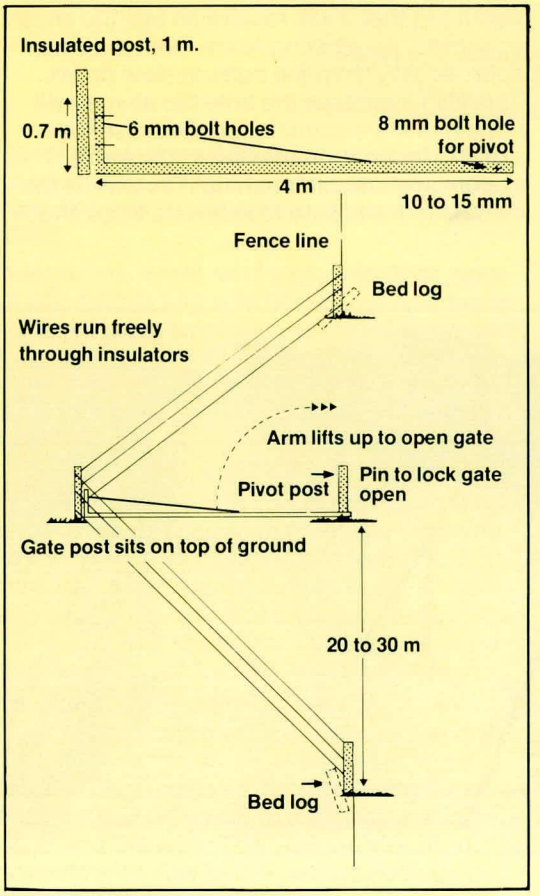
One of the most common faults seen in the construction of dry land electric fences is the lack of attention given to the earth wires in the fence. Because current must travel along earth wires to the earth terminal of the

- *The "Read Lift" or offset arm*
  The Read Lift is a panel of fence, offset from the fence line, which when swung from the horizontal to the vertical position forms a large opening. The opening can be 3 to 5 metres high and 30 to 100 metres wide.
- *Electric drive-through gate*
  This has electrified arms which can be driven through at speeds up to 20 km/hr. A PVC handgrip is provided for pedestrians. The gate can be opened to allow stock movement.
- *Electric spring gate*
  An electrified spring, 30 to 50 mm in diameter connected to an insulated handle, can be stretched across a three to four meter gateway. It is best suited to damp areas.

Conventional gateways
With conventional gateways, both the live and earth wire must be connected to the fence either side of the gate. This is best done by taking the wires underground in 12 mm polythene pipe. The polythene pipe gives the wires protection, and prevents rusting of the wires and voltage loss. Insulated galvanised underground cable should be used for the live wire and earth wires. Each wire should be placed in a separate polythene pipe to prevent induction and voltage loss, and buried at least 30 cm to avoid machinery damage. On each strainer post, the polythene pipe should be bent, as shown to prevent water entering the pipe.

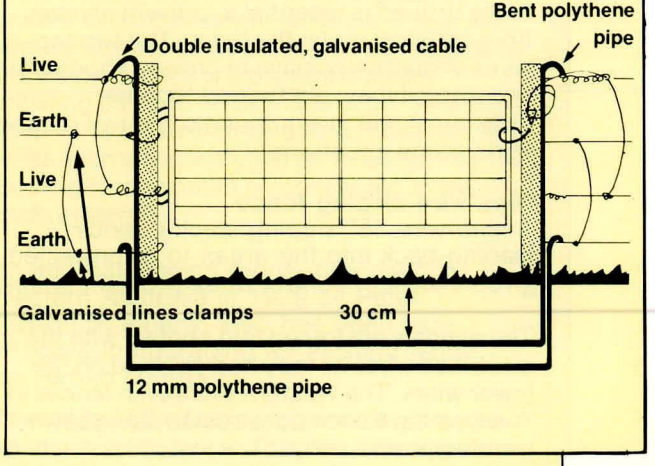
The live and earth wires must be connected, each to each, on either side of the gateway, to ensure maximum current flow. If you fail to do this the current flow will be halved at each gate.

When permanently connecting wires, use galvanised line clamps. These ensure a good connection and a good current flow.



Offset arm lift gate
Material: 32 mm diameter galvanised iron water pipe.
1 only 8 mm x 15 mm bolt, nut washer.
2 only 6 mm x 15 mm bolt, nut washer.
1 post.

By-passing a conventional gate.



ELECTRIC FENCE FARM PLAN

An electric fencing programme is destined to expand. So that future fencing programmes will match in with the current fencing programme, it is important to draw a long-term electric fence farm plan. This should include fence location, electric fence circuits and fence isolation points.

For easy fault finding and to maximise current flow, all electric fence systems should be split into a number of primary circuits, each originating from the energiser. Secondary circuits should branch off the primary circuits, usually on a paddock basis, and should contain an isolating switch. This enables a farmer with a good volt meter to quickly locate the area of his farm where the fault is occurring. By using a number of isolating switches, located on the fence line and a volt meter, faults can be found quickly. If a farmer had 30 kilometres of electric fence with no circuits or isolating switches, he could spend many days locating faults.

Local Government by-laws
Only a minority of Local Government authorities have by-laws relating to electrified roadside fences. Before embarking on an electric boundary fencing programme, notify the Local Government authority and inform it of your intention.

Insurance
Every farmer with electric fencing should have a public risk policy in case of a claim for liability or damage. To date no such claim has been lodged.

Signs
Ensure that neighbours and the general public are aware of electric fences by placing warning signs on such fences. Roadside fences should have a warning sign every 100 metres.

Further reading

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