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A guide to mechanical Range Regeneration

J. Addison

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A GUIDE TO MECHANICAL RANGELAND REGENERATION
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February 1997

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Cover photo – Regeneration on a mini-pond on scalded country.
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FOREWORLD

Degradation of our valuable rangelands is both historical and current (in some areas). The best estimates suggest that about 2 per cent of the Western Australian rangelands used for grazing have been over-used to the point where the perennial vegetation has been completely removed and the soil surface is bare and eroding. It is of greater concern that this degradation has occurred on the most productive pasture types that are usually associated with alluvial plains close to the major rivers or along the coast.

This is both a serious blemish on our past record as rangeland managers and a challenge to the future managers of these lands. This Bulletin provides essential guidance for the people who will take up that challenge. It contains descriptions of the degradation and regeneration process as it occurs in the rangeland environment. It documents the experiences of people who have worked on the rehabilitation of degraded lands over the past 30 years. Using these experiences, the manual provides practical recommendations for the rehabilitation of degraded land.

Western Australian rangeland scientists and managers have made an outstanding contribution to our knowledge of how to rehabilitate degraded rangelands. Beginning with Kevin Fitzgerald’s work in the Ord River Catchment in the 1950s and 1960s, a significant proportion of the Department of Agriculture’s (now Agriculture Western Australia) effort in the rangelands has been directed at the science and practice of rangeland rehabilitation. External funding from the National Soil Conservation Program and the Australian Wool Corporation in the 1980s, associated with the enthusiasm of the emerging Land Conservation District Committees led to an expansion of this work. Much of the material contained in this manual draws on the experiences of this latter period. It is by no means a story of unqualified success. The failures and problems experienced are also explained. For this reason, the manual cautions practitioners about the likely benefits and costs of a rehabilitation program, it adopts a whole-system approach to land management and is not just a list of rehabilitation techniques.

Finally, the problems and costs associated with successful rangeland rehabilitation remind us that the legacy of degradation represents a large loss to the State’s natural resources. We have the opportunity, the knowledge and the will to manage our rangeland resource with sensitivity and care. Curing the problems of the past will be allied with prevention of any re-occurrence.

INTRODUCTION

The main objective of this Bulletin is to describe mechanical methods of promoting rangeland regeneration and how to determine which is the most appropriate to use on any particular site. Mechanical regeneration methods are not ‘quick fix’ but may be used to advantage in some rangeland regeneration strategies.

The basic aim of any mechanical regeneration is to increase soil moisture storage which promotes germination and seedling establishment. Cultivation also creates niches for wind and water borne seed, provides foci for the concentration of organic matter and nutrients and enhances root penetration. Aeration of the soil created by cultivation promotes better drainage.

Mechanical regeneration also breaks surface crusting which is common in degraded soils, allowing movement of water and gases through the soil surface. Surface crusting may prevent or retard seedling emergence.

This Bulletin takes the would-be regenerator through a sequence of steps which, if followed, will improve the chances of success.
Degradation of a landscape occurs when its vegetation, soils and other resources change in a manner that adversely affects its potential for a particular land use such as pastoralism, water yield or wildlife habitat. It is a decline in the productivity and condition of the land, with changes to such things as plant density, biomass and composition, soil stability and nutrient status.

Rangeland degradation occurs in many forms and at various levels of severity. In the pastoral areas the first indicator of degradation is a small reduction in the cover of palatable grasses and shrubs in a pasture. Such a change is readily reversible given reasonable seasons and alterations to stocking management. Severe degradation, with almost complete loss of plant cover and severe soil erosion, is extremely difficult and expensive to reverse.

Degradation in rangelands can result from many causes but pastoralism has undoubtedly been the principal activity responsible for the problem. The history of early settlement in pastoral areas is one of a rapid build-up of stock numbers in the early decades of the century, often on very few permanent waters, to levels now known to be excessive and unsustainable. Loss of palatable grasses and shrubs followed by soil erosion frequently resulted.

The degradation process

Over-grazing, that results in adverse effects on vegetation and soil, will start the degradation cycle. The primary effect of over-grazing is the reduction of plant density and mass that then has indirect undesirable effects on the soil. As the loss of plant cover proceeds, more of the soil surface is left bare and open to wind erosion, rainfall run-off rates increase and water erosion is likely to increase. In addition, reduced soil vegetation cover leads to higher soil surface temperatures, reduced organic matter content, the formation of surface seals and lower infiltration rates of rainwater. The net result of high run-off rates and reduced infiltration is reduced soil moisture stores for plant establishment and growth.

Slight degradation may result from droughts or short term over-grazing but recovery is rapid with a return to better seasons. However, prolonged over-grazing will cause more permanent changes that are more difficult to reverse. Initially the changes may be subtle and difficult to detect or to differentiate from those caused by seasonal variation. The most palatable plant species (decreasers) may be in part replaced by less preferred species (increasers) but overall ground cover remains more or less the same. However, if over-grazing continues the less preferred plants will eventually be removed, ground cover becomes much reduced and accelerated soil erosion begins.

The regeneration process

The regeneration process involves improving the condition or ‘health’ of the soil and vegetation. The basic steps of the regeneration process are outlined in Figure 2. The rate of regeneration will depend on seasonal conditions and the degree of severity of the degradation. Severely degraded sites with poor seed sources and severe soil erosion will recover much more slowly than less degraded sites.
Basic regeneration principles

The basic requirement of regeneration is to implement change in management to encourage the re-establishment of a dense and stable plant cover.

There is one essential requirement for all regeneration programs, regardless of the severity of degradation:

- Control of grazing. This includes the control of grazing by feral and native animals as well as domestic stock. Fences and water supply development must be adequate to exclude grazing from regenerating areas.

A second requirement that may be necessary, depending on the severity of degradation is:

- Some form of mechanical cultivation - to improve soil moisture in the root zone and to provide a niche for the establishment of native and/or introduced plants. Cultivation also decreases water run-off, thereby reducing erosion.

Minor or moderately degraded rangelands

On sites where some stands and seed sources of desirable plant species still exist and where there is little soil erosion the regeneration process can be started and successfully accomplished by careful management. Reduced stocking rates and manipulation of grazing will allow the natural regeneration processes to occur. Experience in pastoral areas indicates that areas of moderate degradation are more likely to recover when one, or a combination of the following occurs over a run of favourable seasons.

- Total stocking rates are reduced (this may include total destocking).
- Total grazing pressure is reduced through additional control of feral animals and kangaroos.
- Some form of deferred grazing or paddock spelling is used.
- Stock control is effective.
- Inequalities of grazing intensity, encountered when a particular paddock encompasses two or more pasture types of different grazing attractiveness, are redressed by re-fencing by pasture type.
- Stock watering points are shut down.

Mechanical operations for regeneration are also an option on minor or moderately degraded range but are not an essential component. They may hasten the recovery process but are expensive.

Severely degraded rangelands

Rangelands in this condition will require mechanical works, as well as grazing control, to start the regeneration process. These rangelands generally have no desirable perennial plants left and therefore will require seeding. Soil is often eroded and degraded with poor physical and chemical characteristics that makes plant establishment very difficult (even with cultivation and reseeding).

Severely degraded rangelands - these saline alluvial plains with eroding surfaces are very difficult environments for plant establishment and are unlikely to recover without special treatments.
Mechanical works are all aimed primarily at:
- providing a favourable niche or seedbed for the establishment of perennial grasses and shrubs;
- ameliorating undesirable soil conditions such as poor infiltration rates and salinity;
- increasing soil moisture stores by harvesting or concentrating water with the objective of successfully establishing vegetation, improving ground cover and reducing erosion.

**STEP 2. IDENTIFYING DEGRADED AREAS**

**Extent of degraded areas**

The extent of the degraded areas on a station can be assessed and measured by remote sensing and/or ground survey. If satellite imagery or aerial photography is available it is possible to identify patterns that indicate different conditions on the land surface. Ground inspection is usually necessary to discover which of these patterns relate to land degradation. Once this is done the boundaries of the degraded areas are drawn on the satellite image or aerial photograph and the area measured. Multiplying the measured area by the scale of the image or photograph will give the extent of the land surface within the degraded area, for example, 2 square centimetres (2 cm x 1 cm) x 1:50,000 scale = 50 hectares.

Where no satellite image or aerial photography is available the extent of the degraded area can be measured by ground survey. A station map or topographic map of 1:100,000 scale (or larger) is required. Driving round the degraded area, allows the boundary to be plotted on the map in relation to known points or features. The vehicle's odometer can be used to measure distances. By using the representative scale on the map, the area of degradation can be determined.

**STEP 3. ASSESS THE DEGRADED AREA**

**Nature and severity of the degradation**

The nature of a degradation problem must be assessed before a management plan for the area can be formulated. Such an assessment of the nature of the problem can be made based on the following checklist. More than one option may be included.

*Loss of perennial plants*

Perennial plant density is less than in other areas of the same pasture type that are in fair to good condition.

*Lowering of the soil surface - water erosion*

Soil deflation and exposure by water of subsoil layers. Signs of broadscale sheet washing and erosion such as microterracing, with remaining plants or stony surface mantle starting to form pedestals, which are typically steep sided.

*Lowering of the soil surface - wind erosion*

Exposure by wind of subsoil layers. The surface may have a ‘polished’ appearance. Rounded hummocks, commonly composed of deposited coarser soil materials, form around plants and other obstacles.
Rilling and gullyng
Caused by concentration of run-off water on exposed soil surfaces.

Accumulation of salt on the soil surface
The soil surface may glisten in bright sunlight. Soft, puffy patches may develop on the soil surface.

Invasion of woody weeds or noxious plants
Such invasions are worth noting for future action (but are beyond the scope of this publication).

Severity of the degradation
The severity of the degradation problem will dictate which management options to employ. In cases of very severe degradation the only physical and financial option is to isolate the area and retire it from all pastoral use.

Water erosion

<table>
<thead>
<tr>
<th>Severity</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>No erosion.</td>
</tr>
<tr>
<td>Minor</td>
<td>Rilling or thin sheeting. Patchy rilling and small gullies affecting small areas or thin sheeting (1 to 2 centimetres) and breaking of the surface seal on parts of the site. Some redistribution of soil and litter downslope. Much undisturbed ground between affected areas.</td>
</tr>
<tr>
<td>Moderate</td>
<td>Gullies and/or sheeting on lower slopes. Gullies on the lower slopes or more susceptible parts of the site, these being capable of extension to less susceptible areas. The gullies may be associated with extensive but discontinuous disturbance of the soil surface by sheet erosion and redistribution of soil material.</td>
</tr>
<tr>
<td>Severe</td>
<td>Terracing or extensive gullies. Severe sheeting or terracing affecting nearly all of the site. Redistribution of soil and exposure of subsoil or rock material. The sheeting may be associated with or replaced by very extensive gullyng over most of the site.</td>
</tr>
</tbody>
</table>

Pasture condition

<table>
<thead>
<tr>
<th>Pasture condition</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>Nearly all plants present are desirable species and ground cover is optimum for the site.</td>
</tr>
<tr>
<td>Good</td>
<td>Most plants present are desirable with intermediate perennials and annual types increasing in frequency; a few undesirable species may be present.</td>
</tr>
<tr>
<td>Fair</td>
<td>Intermediate value species usually predominate; desirable and undesirable species occupy similar proportions of the available ground space.</td>
</tr>
<tr>
<td>Poor</td>
<td>Undesirable and intermediate species predominate in the stand; desirable species are very infrequent and may occur only in small patches. The overall stand may be sparse with ground cover well below optimum for the site.</td>
</tr>
<tr>
<td>Very poor</td>
<td>Undesirable species or bare ground predominates; there are few intermediate species and virtually no desirable species in the stand.</td>
</tr>
</tbody>
</table>

Wind erosion

<table>
<thead>
<tr>
<th>Severity</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>No erosion.</td>
</tr>
<tr>
<td>Minor</td>
<td>Litter build-up and small scalds. Small isolated scalds on which the surface shows some degree of polishing. Redistribution of soil to the margins of scalds, or minor build-up of soil material around obstacles.</td>
</tr>
<tr>
<td>Moderate</td>
<td>Large isolated scalds and hummocks. Stripping of the soil surface and build-up against obstacles associated with large but generally discontinuous scalds; or numerous small scalds scattered throughout the site.</td>
</tr>
<tr>
<td>Severe</td>
<td>Major deflation of soil surface. Active stripping resulting in large continuous scalds with polished and sealed surfaces. Frequent large hummocks against obstacles. Major dune drift in sandy systems. Plant cover extremely sparse to absent.</td>
</tr>
</tbody>
</table>

Source: Payne et al. 1982
**STEP 4. IDENTIFY AND CONTROL THE CAUSE OF DEGRADATION**

Isolating degraded areas

Degraded areas will require special management. This means total grazing exclusion or opportunistic grazing. Either way, the degraded area(s) should be isolated. Degraded areas were sites of preferential grazing. Such preferential grazing may continue, even on degraded areas, unless they are isolated from other parts of the station.

When planning to fence off degraded areas into separate management units, you need to consider how the rest of the station will function. Access to water points and normal mustering routes may be interrupted. Water points may have to be moved or water piped to new locations. Mustering programs may need revision. Thus the costs of polyethylene pipe, tanks, troughs and portable yards are hidden costs in the regeneration process.

Removing causes of degradation

When an electric fuse blows, you check and remove the cause of the overload before repairing the fuse. Similarly one should identify the cause of the initial degradation problem and remove or control it before spending money on regeneration programs. If the source of the problem is not removed or controlled, money will be wasted. What ever has degraded some areas of the station could degrade other areas. Use the following table to develop whole station management.

Removing the cause of the degradation problem is vital, and this action alone will often result in a regenerative response.

<table>
<thead>
<tr>
<th>Cause</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overstocking in drought</td>
<td>Develop a station policy to reduce stock numbers progressively as drought conditions worsen.</td>
</tr>
<tr>
<td>Fire</td>
<td>Develop fire management strategies e.g. firebreaks.</td>
</tr>
<tr>
<td>Excessive grazing pressure</td>
<td>Destock burnt areas to allow pasture recovery.</td>
</tr>
<tr>
<td>Domestic animals</td>
<td>Impose management strategies which maintain productivity but reduce grazing pressure.</td>
</tr>
<tr>
<td>Feral animals</td>
<td>Market aggressively, fence out, shoot on sight.</td>
</tr>
<tr>
<td>Native animals</td>
<td>Reduce population to a sustainable level (acceptable to the wider community).</td>
</tr>
<tr>
<td>Devastating flood</td>
<td>Form a catchment group to plan and implement run-off control, starting in the headwaters.</td>
</tr>
</tbody>
</table>
Grazing animal control

Control of grazing animals (domestic and feral) is essential if mechanical regeneration efforts are to be successful. An initial 'total' destock will promote a build-up of surface mulch and increase vegetative protection of the soil surface. This leads to improved infiltration of rainfall which enhances perennial grass and shrub establishment. Destocking will improve perennial plant vigour and will increase seed production from remnant vegetation in degraded area.

Grazing animals often select young palatable plants establishing on earthworks, retarding perennial plant re-establishment. Physical damage by grazing animals reduces the effectiveness of the earthworks.

As the regeneration process advances, limited restocking may be appropriate and beneficial. However, if there is not complete grazing control, regeneration may be halted (or reversed).

Fences

Isolating degraded areas by fencing is a common method of gaining grazing animal control. Fences should be sited to enable the degraded area to be operated as a management unit. Siting of divisional fences should aggregate similar country types into paddock or management units. Having a trap yard on a water-point is useful in keeping regeneration areas destocked; stock and feral animals that go through the fences can be trapped and removed.

Stock watering points

Grazing pressure on a given area may be removed by placing that area outside the stock grazing radius from a watering point. This may require the closing down of a bore, the fencing out of a natural water supply or the relocation of a supply using a pipeline.
Having identified the extent and cause of the degradation, removed or controlled the cause, and isolated the area from the rest of the station for special management, you must now decide what regeneration strategy to adopt. To do this you need to look in more detail at site characteristics.

**Topographic considerations (slope)**

The choice of regeneration strategy will depend on the position in the landscape occupied by the degraded area. Some areas will be suitable for cultivation; others will not, and will require other on-site and off-site management.

<table>
<thead>
<tr>
<th>Position in the landscape</th>
<th>Recommended action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hill slopes (steep or moderately inclined)</td>
<td>Not suitable for cultivation</td>
</tr>
<tr>
<td>Foot of hill slopes (gently inclined)</td>
<td>Assess feasibility of installing structures to control run-off from the hills above. Establish seed source areas in enclosures.</td>
</tr>
<tr>
<td>Plains and gentle slopes not subject to flooding</td>
<td>Assess suitability for cultivation, seeding and water-ponding. (See following pages on soil and other considerations and ‘Decision tree’ page).</td>
</tr>
<tr>
<td>Large, active flood plains (little slope)</td>
<td>Control dry season watering points. Graze if and when seasonal conditions allow. Investigate possibility of controlling run-off starting at the head of the catchment.</td>
</tr>
</tbody>
</table>

**Soil consideration (see ‘Decision tree’ page 13)**

It is always more difficult to achieve plant establishment in degraded soils than in those that are not degraded. This is because the remaining soil is chemically and/or physically inferior.

**Soil chemistry**

**Soil sodicity**

A chemical imbalance in some clay soils causes them to set hard when dry, but when wet there is a structural breakdown causing the soil to slump and the surface to seal. These unstable soils exhibit very low water infiltration rates and high levels of run-off. Cultivation of such soils has been found, in some areas, to produce only a short-lived benefit to plant establishment. Mulching or gypsum application will improve these soil conditions, but is seldom financially practical. Conversely, water-ponding causes sodic clay soils to crack more intensely when they dry out. Over four or five years this slowly improves water infiltration and promotes plant establishment and persistence.

Indications of a sodicity problem can be inferred from a high soil pH. As a rough guide soils with a pH above 8.5 (alkaline) are likely to be sodic and soils with a pH of 9 or above are highly likely to be sodic. Soil pH can be measured by using a simple soil test kit available from commercial outlets.

**Soil salinity**

Salinity can be identified in the field by the presence of patches of crusted surface overlying soft 'puffy' material. Salt crystals may be evident in the soft material and the crust may have the appearance of having been dusted with icing sugar. Salt tolerant plants such as samphire, frankenia, annual saltbush and perennial ricegrass may also be present.

An electrical conductivity meter used to check the salinity of bores can also test soil salinity using a level tablespoon of soil (10 g) in half a baby food jar (50 ml) of rain water or distilled water (1:5 soil:water suspension).
The assessment of salinity for a 1:5 soil:water suspension depends on soil texture (see below for descriptions of texture). A reading greater than 50 milliSiemens per metre (mS/m) for clays indicates at least moderate soil salinity. For loams and for sands, greater than 35 mS/m and greater than 25 mS/m, respectively indicates at least moderate salinity.

Soil salinity will limit the choice of species, and in severe cases nothing will grow. Even salt tolerant species may have difficulty establishing because germinating seed and seedlings are less salt tolerant than mature plants.

On very gentle slopes water-ponding has proved effective in decreasing salinity. When a soil is both saline and sodic, water-ponding is preferable to other forms of cultivation, provided the slope is gentle. In the case of a saline soil overlying a soil texture contrast (e.g. sandy loam over clay) occurring at less than 50 centimetres, ponding is not recommended because it is likely to make the site more saline. In this case deep ripping or contour ridging would be the preferred options if cultivation was necessary.

Rangeland soils are inherently low in plant nutrients such as nitrogen and phosphorus. Degraded soils have even lower levels. However, only in extreme cases would infertility of the soil be a consideration or a constraint for the establishment of rangeland species. This is because of the high cost of fertiliser and because many native plants are adapted to low fertility soils.

**Soil texture**

Soil texture is generally related to the proportion of soil particles of differing sizes (sand, silt, clay and gravel) in a soil, but is also influenced by organic matter content, clay type, and degree of structural development of the soil.

For field identification, take a small handful of soil and knead with water until a soil ball or bolus is obtained. The bolus should be kept moist so that it just fails to stick to the fingers. The six main texture groups should be apparent as follows:

1. Sands (approx. clay content, less than 5 per cent) have very little or no coherence and can not be rolled into a stable ball. Individual sands grains adhere to the fingers.

2. Sandy loams (10-15 per cent clay) have some coherence and can be rolled into a stable ball, but not a thread. Sand grains can be felt during manipulation.

3. Loams (20-25 per cent clay) can be rolled into a thick thread, but this will break up before it is 3-4 millimetres thick. The soil ball is easy to manipulate and has a smooth spongy feel with no obvious sandiness.

4. Clay loams (30 per cent clay) can be easily rolled to a thread 3-4 millimetres thick, but it will have a number of fractures along its length. Soil becoming plastic, capable of being moulded into a stable shape.

5. Light clays (35-40 per cent clay) can be rolled to a thread 3-4 millimetres thick without fracture. Plastic behaviour evident, smooth feel with some resistance to rolling out.

6. Heavy clays (45 per cent clay) can be rolled to a thread 3-4 millimetres thick and formed into a ring in the palm of the hand without fracture. Smooth and very plastic, with moderate-strong resistance to rolling out.

Soil texture will determine the choice of species to be used in a particular environment. Texture will also indicate the likely ability of the soil to take in and hold moisture with loams and clays holding more moisture than sands. Texture contrast soils (e.g. sandy loam over clay), tend to have limited moisture holding capacity, become easily waterlogged, produce high levels of run-off once they are saturated, and may concentrate any salt present in the soil on the soil surface. Degraded self mulching soils (crabhole soils and blacksoils) should only require the presence of a seed source and appropriate grazing control to bring about regeneration.

Assess soil conditions to answer these questions: (which are addressed later in this manual)

a) Will plants grow on this site, and if so, which species?

b) Will cultivation or water-ponding improve the situation, and encourage plant establishment?

c) What soil amelioration might be needed after cultivation to encourage plant establishment and persistence?
Seed source considerations

The provision of seed can account for half the cost of a mechanical regeneration program. Seed should only be applied where necessary, and then in such a way that will maximise its long-term benefit. Seed is necessary when there is no stand of perennial plants nearby to form a seed source.

Where natural, healthy stands of perennial plants flank the degraded area it is not necessary to apply seed. Instead, cultivate progressively away from the natural seed source. This cultivation would need to be undertaken over a number of years, only cultivating each year as far as the naturally occurring seed will disperse. As a rule of thumb, if strip cultivation is employed, cultivate only five strips out from the seed source in the first year.

Do not spread seed over areas of water-ponding until an improvement in soil condition is evident. Even then it is advisable to only place seed on the bank itself at about the high water mark. This will develop into a seed source for the rest of the ponding system at minimum cost.

Will it make a dollar?

An understanding of the costs and benefits of mechanical regeneration is useful in several ways. First it allows the situations that provide the best return on investment to be identified and these priority areas can be treated first. It also indicates the maximum level of investment that can be afforded to regenerate any one area. For example, a soil or pasture type may not show a positive return on investment if the mechanical regeneration costs more than a certain amount per hectare. Mechanical rangeland regeneration is an expensive operation, that has high initial costs and a long term response.

Economic assessment should be on a whole paddock basis, and the benefits that regeneration has over that whole paddock.

Regeneration by management alone, using spelling and low stock numbers, is relatively inexpensive but may take a long time for pasture recovery. Because this approach involves a longer time frame, some productivity will be foregone during recovery. Some severely degraded areas will only recover with the aid of mechanical work.

There is limited knowledge on the costs and benefits of mechanical regeneration and the response rates on various soil types is not well known.

When planning to do something about degraded areas it is suggested that the following points are considered:

- First, if practical, fence the degraded country into a discrete area.
- In most cases mechanical regeneration will provide, at best, only moderate to low rates of return on money invested.
- In many cases the return will be positive, but there may be a negative rate of return.
- As the margin per livestock unit (LSU) increases, then benefit from regeneration increases.
- Country with better potential carrying capacity will provide a better return on the investment in mechanical regeneration.

A case study analysis of the Myroodah land system in the Kimberley region suggests that the following approach will maximise the value of the investment in mechanical regeneration.

- Regenerate high value paddocks, where the margin per LSU is better. (Regeneration may increase the margin by allowing more cattle to be run in the same paddock). High value areas may be weaner paddocks, horse paddocks, holding paddocks, homestead areas or very productive pasture areas.
- It is better to regenerate paddocks that only have small degraded areas that are limiting production.

Mechanical regeneration may also have a valuable role in controlling dust around homesteads and cattle yards.

Increasingly, the prevailing range condition of a pastoral lease is being used by potential buyers as a significant component in property valuation. As more demonstration work is carried out a better idea of the response rates and the cost of doing the work will be available. This will enable better economic analyses to be made.

Research has shown that some particular soil types are very difficult to regenerate even with mechanical regeneration. It is best to first tackle the lower risk areas where the possibilities of a good response are known.
### Decision Tree (a strategy guide)

<table>
<thead>
<tr>
<th>Soil chemistry</th>
<th>Soil texture</th>
<th>Soil depth</th>
<th>Soil surface slope</th>
<th>Residual seed source</th>
<th>Regeneration strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sodic or sodic/saline (unstable)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Install ponding banks</td>
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<td></td>
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<td></td>
<td>Present Manage for perennial plant recruitment Install contour ridging cultivation</td>
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<td></td>
<td></td>
<td>&lt;0.5%</td>
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<td></td>
<td>Establish exclosed seed source areas (cultivate, apply gypsum, seed and mulch)</td>
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<td></td>
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<td>0.5 - 5.0%</td>
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<td>Absent</td>
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<tr>
<td><strong>Saline (non-sodic)</strong></td>
<td>Depth to texture contrast (i.e. depth to clay layer)</td>
<td></td>
<td>&lt;0.5 m</td>
<td></td>
<td>Deep contour ripping or ridging</td>
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<tr>
<td></td>
<td></td>
<td>&gt;0.5 m</td>
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<td></td>
<td>Establish exclosed seed source areas</td>
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<td></td>
<td>Texture contrast</td>
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<td>0.5 - 5.0%</td>
<td></td>
<td>Manage for perennial plant recruitment</td>
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<td></td>
<td></td>
<td>Absent</td>
<td>Establish exclosed seed source areas</td>
</tr>
<tr>
<td></td>
<td>Uniform profile (i.e. same texture throughout profile e.g. all sandy loam, all loam etc.)</td>
<td></td>
<td>&lt;0.5 m</td>
<td></td>
<td>Manage for perennial plant recruitment</td>
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<td></td>
<td></td>
<td>Absent</td>
<td>Establish exclosed seed source areas</td>
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<tr>
<td></td>
<td>Self mulching clays (crabboles and/or blacksoils)</td>
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<td><strong>Non-sodic</strong></td>
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</table>
STEP 7. IMPLEMENTING THE STRATEGY

Surveying requirements

A topographic survey of the degraded area is essential before starting earthworks. Failure to adequately survey will lead to major reductions in the effectiveness of the earthworks and may accelerate soil erosion.

Most forms of regeneration earthwork designs require contour surveying. A contour line is an imaginary line joining points that are the same height above sea level. Run-off flows at right angles to the contour line.

'Key' contour lines are surveyed and pegged across the area of degradation. The machine operator constructs the appropriate earthworks on these lines first as these are to be guides by which all the earthworks will be accurately located. The distance between key contours will depend on a number of factors.

(a) The constant grade of the slope - the more constant the grade the fewer key contours required.

(b) Slopes greater than 0.5 per cent require close spacing because cultivation deviating from the contour may lead to soil erosion.

(c) Skill level of the machine operator. An experienced operator who is able to 'read' the ground surface may be able to accurately operate with wider spacings.

Run-off direction relative to contour

![Diagram showing run-off direction relative to contour lines]

**Relationship between direction of run-off and contour lines**
Placement of key contours

Diagram to illustrate 'key contour' surveying

Where key contour lines are much further apart at one end than the other (see sketch) the machine operator must carry out a series of bisections to ensure that the earthworks are on the contour.

Key contour bisection

Maintaining earthworks on the contour with diverging key contours
Instrument surveying is speedier if the surveyor is able to 'read the ground'. Telltale signs on the ground indicate direction and magnitude of overland flow.

**Diagram:**
- **Reading the ground (a) Flotsam on the contour**
  - Major run-off
  - Minor run-off
  - Organic matter and micro terracing

- **(b) Sediment 'tail' behind obstacle**
  - Minor rilling
  - Obstacle
  - Sediment tail

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(a) Key contour lines are surveyed, across the area to be ponded, at a vertical interval of 8 centimetres.

(b) The ends of the ponding banks are then surveyed to give a maximum ponding depth of 8 centimetres.

(c) Neighbouring ponds should have a gap of 15 metres between them to allow for pond overflow.

(d) Ponds should 'cover' each other, in a brick-pattern design, across the area to be regenerated.

(e) Maximum open pond size should not exceed 0.4 hectare.

Ponding banks must be checked on completion to ensure that there is sufficient freeboard. Freeboard is the vertical difference between static water level and the top of the bank.

Rule of thumb - Freeboard to be five times maximum ponding depth.

NB: Banks will lose 10 per cent of height on settling.

Water erosion of banks will reduce effective height.

Large ponds are subject to damage by wave action.
Closed ponds

Maximum size should not be greater than one hectare (i.e. 110 metres diameter).

Earthworks design

The basic aim of any mechanical regeneration is to increase soil moisture storage to promote germination and establishment. Cultivation also creates niches for wind and water borne seed, provides foci for the concentration of organic matter and nutrients and facilitates root penetration. Aeration of the soil created by cultivation promotes good drainage.

Mechanical regeneration also breaks surface crusting that is common in degraded soils, allowing the movement of water and air through the soil surface. Surface crusting may arrest or retard seedling emergence.

Ripping

Rippers typically comprise a trail mounted, rectangular box section tool frame with up to three tool bars. Ripper shanks are mounted in various configurations on the tool bars. Ripper shanks should be spaced at 50 centimetres centres laterally and staggered longitudinally to allow the implement to draw straight and evenly. Ripping should shatter the soil to a depth of 30 centimetres without inverting the soil. Any inversion of the soil may bring undesirable materials to the surface. Ripping benefits a range of soil types. It is least effective on sandy soils and heavier textured (clay) soils which tend to seal rapidly after cultivation.

If 30 centimetres depth is unobtainable, the lateral spacing of the ripper shanks should be reviewed and more shanks attached to the tool frame.
Ripping should always be carried out on the contour and should never cover 100 per cent of the area.

This brick pattern ripping on the contour, made using a chisel plough, holds water and provides a seedbed for plant establishment.
Brick pattern cultivation

The system recommended gives a 60:40 run-off:run-on ratio and maintains overall surface stability.

Run-off not absorbed by the ripping will generally find its way through the maze of ripper workings without causing damage to the cultivation. Slowing down run-off also promotes greater total rainfall infiltration.

**Ridging**

Ridgers are essentially rippers with a pair of opposed discs mounted on the rear toolbar. Ridging combines two operations in a single pass:

- ripping,
- ridging with opposed disks forms a substantial barrier to overland flow.

The bank created by ridging provides niches for germination and establishment, adjacent to furrows that collect run-off and promote infiltration.

Ridging benefits all soil types except those which are highly dispersive.

Regeneration on ridging on severely degraded rangelands.
Shanks shatter soil in front of opposed discs

Opposed discs

Central ripper shank

Outlyer shank

Shanks shatter soil in front of opposed discs

Direction of travel

Central ripper shank

Ridging – tool frame plan

Ridge created by opposed discs

Seed placement

Furrow collects run-off

Moisture infiltrates shatter zone

Ridging – cross sectional view
Pitting

Pitting is carried out by either a tined implement or by discs with a section removed. Discs must operate in gangs of at least two to ensure continuous rotation.

Furrows

Tine pitting - earthworks (plan view)

Tine pits are created as tines intermittently engage the soil. Disc pits are created as the cutting edge of an offset disc turns, soil is not cultivated where the disc has been cut away. Pitting is suited to lighter textured soils. The pits create niches for seed and temporary storage sites for run-off. The stored water infiltrates from pits to the surrounding soil. Contour working gives the best result as pits are aligned at right angles to any overland flow.

Pitting may be used over all of a degraded area and typically gives an 80:20 run-off: run-on ratio. Mechanical pitting does not require as much drawbar power as ripping and work rates are higher because of greater machine speed.

Furrowing

Furrowing has been used in some parts of Australia (particularly New South Wales) to regenerate deep, friable soils. In Western Australia, a grader blade is generally used for furrowing, it creates a bank of earth on the downslope side and a furrow on the upslope side. The grader blade turns soil loosened by ripper tines, in a single pass operation. The bank provides niches for seed entrapment and forms a barrier to run-off. The furrow collects run-off to enhance subsoil moisture storage. Furrowing is done on the contour. If the ends of the banks are turned upslope slightly, ponding behind the bank will occur, further helping infiltration.

Medium sized tractor with disc pitter and drum type seedbox at work on bare plains.
Ponding

Ponding is a regeneration technique developed in western New South Wales to regenerate ‘flat’ scalds. Ponding increases available moisture for plant growth but has not shown itself to be generally successful on sodic clay soil unless internal cultivation is also used. Investigations to date in the Kimberley suggest that ponding to a maximum depth of 8 centimetres with a mix of ripping and ridging promotes the reestablishment of perennial species.

It is suggested that the area be strip ripped and ridged before bank formation with a grader.

Active flood plains are unsuitable sites for ponding.

Open ponding is used on gently sloping sites where rainfall run-off can be harvested from upslope. Closed ponding is used on flat sites or those with little slope. Rainfall run-off is only harvested from within the pond itself.

Ponding banks being constructed with a road grader on almost level degraded rangelands.
The method of surveying 'open' and 'closed' ponds is detailed in the section on surveying. Five passes with the grader are usually required to build a bank of sufficient height and width to withstand settlement, wave action and weathering. Care must be taken when constructing the corners (see Win sketch plan). These are usually the lowest part of the bank on completion and have to take the worst of the wave action (because of the funnelling effect of adjacent banks).

**Combinations**

The combinations of ripping and ridging, and ponding with ripping and ridging have already been mentioned. There are three other combinations that have achieved success under some circumstances.

**Ripping and pitting**

This technique has been used successfully in the Western Australian shrublands in clay loam soils. Here, ripping in front of pitters has created surface and subsurface moisture storage together with a good seed bed. A slight ridging effect is created which also assists in promoting water infiltration by slowing overland flow.
**Ridging and ponding (scalloping)**

This technique is usually known as scalloping. It consists of ridging but instead of staying strictly on the contour, the ends of the ridges are turned uphill to create mini-ponds.

![Scalloping - earthworks (plan view)](image)

**Chisel cultivation in successive seasons**

Kimberley experience is that re-cultivation in the following year aids implement penetration and greatly promotes vegetative response.

**Seed and seeding - summer rainfall areas**

**Choice of species**

This depends on three main factors:
- soil type,
- rainfall,
- soil fertility.

Near rivers, the likelihood of flooding may also influence species choice.

**Bull Mitchell grass** (*Astrebla squarrosa*) is suited to heavy clay soil and black soils in areas with annual rainfall between 400 and 650 millimetres. It is a perennial tussock grass which responds quickly to rainfall even after a lengthy dry period.

A native to northern Australia, Bull Mitchell grass is useful in regeneration work because it is resistant to grazing, and drought.

**Weeping Mitchell grass** (*Astrebla elymoides*) and **barley Mitchell grass** (*A. pectinata*) are suited to similar environmental conditions as bull Mitchell but are less resistant to grazing because of their higher palatability. They are the preferred species.

**Mimosa bush** (*Acacia farnesiana*) provides valuable ground cover and 'top feed' but may develop into thickets. It is suited to a range of soil types where annual rainfall is below 600 millimetres.

**Birdwood grass** (*Cenchrus setiger*) and **Buffel grass** (*C. ciliaris*) are tussocky perennial grasses originally from Afghanistan and introduced into Western Australia in the 1880s. They can be used on lighter soil where the annual rainfall is between 250 millimetres and 700 millimetres and are able to colonise degraded sands and loams found on levee crests. Both species respond quickly to storms in the build-up to the wet season.
Other native perennial grasses that have potential for regeneration in summer rainfall areas include **Roebourne plains grass** (*Eragrostis xerophila*), **neverfail grass** (*Eragrostis setifolia*) and **blue grasses** (*Dichanthium* species). However very little work has been undertaken with these species in Western Australia.

**Kapok bush** (*Aerva javanica*) is a small shrubby perennial introduced into Australia late last century. It is a useful initial coloniser on red soils, gravelly soil and limestone areas. Copious quantities of seed are produced, but this has a low germination rate (around 2 per cent) unless freeze treated. Kapok is very drought resistant.

### Obtaining seed

Most seed can be obtained from seed producers but this is expensive and seed may not be best suited to a particular area. The best seed is local seed, as it is suited to that area. Mitchell grasses, kapok and mimosa bush seed can be harvested by hand or machine. Buffel and birdwood seed are harvested using beater type harvesters, or more conventional agricultural harvesters.

### Seed storage

After harvesting bulk seed should be turned regularly to promote even drying. Seed must be protected from moisture and pests (such as insects or mice). If moisture gets in, the seed will become affected by mildew and heat up. Most seed has its maximum germination percentage about 12 months after harvesting, following which germination rate decreases.

### Time of seeding

Ideally, seed should be sown after the initial rains of the wet season have built up the moisture content of the soil and follow-up rains are expected. This is only practical for very small areas. For larger areas, sow as close to the start of the wet as practical. Sowing too early allows theft by birds and insects. Too late, and the machinery will be bogged.

### Seeding rates

Seed species may be applied individually or as a 'shotgun mix'. Higher rates give faster establishment but this may not be economical.

- **Birdwood grass** 3-10 kilograms per hectare
- **Buffel grass** 2-5 kilograms per hectare
- **Mitchell grasses** 5-7 kilograms per hectare
- **Kapok** 2 kilograms per hectare
- **Mimosa bush** 1-2 kilograms per hectare

Where a shotgun mix is used, the lower rates of individual species should be used. Shotgun mixes should contain seeds of similar size and density to avoid uneven distribution during seeding.

### Seed treatments

The germination rate of kapok bush is greatly increased by holding the seed at about 5°C under moist conditions for two to three weeks before sowing. Acacia seed germination is increased by heat treatment i.e. immerse seed in water at 80°C for two minutes, remove and allow to cool rapidly by placing in a freezer for ten minutes. Rapid temperature change promotes seed coat cracking.

Successful regeneration on degraded Kimberley rangelands (summer rainfall area). Buffel and Birdwood grasses well established on rip and ridge cultivations (left) and kapok bush establishing as a primary coloniser on workings on calcareans soils.
Seed placement

Seed should be placed where it will germinate freely, establish quickly and survive. This in practice means in soil with high moisture availability, but not where waterlogging might occur. Seeds and seedlings placed in soils which are 'wet' for any length of time will die. Most grass seeds should be placed between 0.5 centimetres and 2.0 centimetres below the soil surface. Smaller seeds need to be close to, but not on the surface. Legumes, such as acacias, require a rough uneven surface but don't need to be buried.

Seed and seeding - winter rainfall areas

Choice of species

Selecting the correct species for regeneration in winter rainfall areas will depend on:

- the purpose of regeneration;
- soil type;
- position in the landscape.

If the purpose of regeneration is to provide grazing for domestic stock, then hardy, long-lived, palatable species should be chosen. Saltbush (Atriplex species), bluebush (Maireana species) some cotton bush (Ptilotus species) and wattle (Acacia species) are well suited to regeneration for grazing.

Regeneration for amenity purposes, such as around homesteads to stabilise degradation, reduce dust and improve aesthetics would use a wider range of species. In this instance, stock preferences need not be taken into account.

Heavy and medium textured saline soils (e.g. loamy clays) subject to seasonal flooding, can be regenerated for grazing, with species such as river or swamp saltbush (Atriplex amnicola), silver saltbush (Atriplex bunburyana) and spiny bluebush (Maireana aphylla).

Heavy textured saline soils that are not seasonally inundated can be regenerated with the same species and others, such as bladder saltbush (Atriplex vesicaria), and sago bush (Maireana pyramidata). River saltbush and spiny bluebush planted on such sites will be drought prone and less successful unless additional water is harvested using earthworks.

Heavy and medium textured non-saline soils can be regenerated for grazing by the same species as heavy textured saline soils, as well as species like cotton bush (Ptilotus obovatus), felty bluebush (Maireana tomentosa), Georges bluebush (Maireana georgei), mulga bluebush (Maireana convexa) and three winged bluebush (Maireana triptera). Other desirable forage plants such as currant bush (Scaevola spinescens) have been observed regenerating heavy textured soils (saline and non-saline) naturally. Despite this, no success has been achieved by reseeding this species.

Light textured soils (e.g. sands, loamy sands and loams) tend not to be saline and are suited to revegetation for grazing by species such as buffel grass (Cenchrus ciliaris), Birdwood grass (C. setiger), cotton bush, felty bluebush and three winged bluebush. On duplex soils, where light textured soils are underlain by heavier soils, regeneration using most of the saltbushes and bluebushes is possible.

Results of a direct seeding experiment with gypsum and bladder saltbush on graded furrow in the Murchison rangelands.
Regeneration of these soil types for amenity purposes can be achieved by a wide range of species including those already mentioned. Tree species such as prickly acacia (Acacia victoriae), wait-a-while (Acacia cuspidifolia), curara (Acacia tetragonophylla), mulga (Acacia aneura), limestone wattle (Acacia sclerosperma) and needlebush (Hakea preissii) would be suited to heavier textured soils.

Species for lighter soils would include those mentioned for regeneration for grazing and species such as sandplain wattle (Acacia murrayana), poverty bushes (Eremophila forrestii, E. margarethae and E. maitlandii), pebble bush (Stylobasium spathulatum) and flannel bush (Solanum lasiophyllum).

Obtaining seed

Seed can be obtained by collecting it personally or by purchasing from local seed merchants and the larger commercial seed merchants.

It is preferable to use seed collected locally as it is more suited to local conditions.

Pragmatism should rule seed purchases: if local seed is unavailable, purchase elsewhere. Don’t buy seed without being provided with the results of a recent germination test. Unless it is tested, you may unwittingly buy dead seed.

Seed storage

Seed should be dried before storage, otherwise fungal growth can reduce viability. Seed collected on the station should be cleaned to remove green leaf and stick material. This will reduce the drying time. Excessive amounts of stick and leaf material will also cause problems with seed flow when seeding.

Seed should be stored carefully to maximise its longevity. Storing seed in airtight containers and keeping it cool will also extend seed life.

Insect damage can be controlled by including a pest strip (e.g. chopped up pet flea collar) in storage containers. The natural life of seed varies with species. Acacia seed is very long lived (more than five years) and most saltbush and bluebush seed will survive two or three years under ideal storage conditions.

River saltbush seed will survive storage for up to five years. Seed of other species, such as silver saltbush, will not survive more than 18 months.

Time of seeding

In areas that normally receive summer rain, cultivate and sow seed before rain is expected. Successful regeneration is often ensured by following winter rains.

Those areas that don’t normally receive summer rain should be sown before the onset of winter rains. When regeneration requires natural seed spread, cultivation should occur before seed drop.

Seeding rates

The rate of seeding depends on:

- seed quality
- physical character of the seed (size, density, etc.)
- price of seed.

Rates will vary depending principally on the germination percentage, purity of seed and the size of seed (number of seeds per kg). For example, if seed is more than 80 per cent pure and greater than 80 per cent germinable, then rates of up to 4 kilograms per hectare would apply to buffel and birdwood grass, and up to 2 kilograms per hectare for saltbushes and bluebushes. If the quality of seed was less than this, however, rates would change according to the reduction in quality. Rates would be doubled if seed was 50 per cent pure, with a germination rate of 40 per cent.

It is preferable to sow a mixture of species. As species all differ in their requirements for germination and establishment, and climatic conditions are unpredictable, sowing a mixture will reduce the risk of failure.

The total sowing rate for shrubs, would be up to 2 kilograms per hectare when mixtures of species are sown.

Seed treatments

The germination of acacia seed is enhanced by seed treatments such as scarifying the seed coat with sandpaper, or placing in hot water (about 80°C) for a few minutes.

Saltbush, bluebush and cotton bush seed requires no treatment before sowing. If seed theft by ants is likely, treat the seed with an insecticide such as malathion.
Seed placement

To maximise germination and establishment, seed must be placed in favourable niches. Generally, this means directing seed onto the areas of cultivation with the greatest soil moisture (without being waterlogged) or with that potential when sown dry.

Saltbush and bluebush seeds do not require burial. Germination will not occur with these species if seed is buried under more than a few millimetres of soil. It is safer to place the seed on top of the cultivated ground. Acacia seed will germinate satisfactorily when sown onto a roughened surface.

With pitting, seed should be placed into the pits. As the pits fill with water the lighter, fluffier saltbush and bluebush seeds float and when the water level recedes, are left in the desired niches on the upper faces of the pit.

Seed placement for furrowing, is similar to that for ridging. With furrowing, seed should be concentrated on the upslope side of the bank, at the interface between bank and ponded water (at maximum depth).

For all cultivations, avoid placing seed where it will become waterlogged, as seed and seedlings will die.

Looking after the investment

Mechanical regeneration is not an operation which on its own fixes range degradation problems. To ensure that a return is to be had from the considerable expense that goes into the operation there needs to be appropriate grazing strategies put in place to ensure an improving range condition trend.

These strategies should ensure that grazing pressure is applied in a conservative fashion especially in the early years following the mechanised work.

To assist this grazing management it is recommended that photographic range monitoring sites be installed and annually re-photographed so that grazing strategies might reflect pasture condition and growth more accurately.

Agriculture Western Australia is able to assist in the installation of these sites.
CASE STUDIES IN RANGELAND REGENERATION

1. Saltbush/bluebush country regenerated by grazing management

In this case, the pastoralist chose to regenerate a portion (about 5 square miles or 13 square kilometres in area) of an old holding paddock in which the palatable perennial shrubs had been grazed out. He wanted to create a ram paddock to graze in rotation with another paddock.

The holding paddock comprised of stony hills (Two Hills land system) to the west and broad, gently sloping plains (Jimba land system) receiving sheet and channelled flow, to the east.

The pastoralist considered that by fencing according to land system boundaries and destocking, the broad, gently sloping plains would regenerate naturally. He based this view on experience and the fact that the area was wash country, with soft, deep soil that had once carried saltbush and bluebush pasture. In addition, there was also an excellent source of saltbush seed upslope of the denuded area.

Given these factors, he fenced the area of Jimba land system and removed the sheep. The area was then spelled from grazing by sheep for seven to eight years. During this time, the area was only grazed by kangaroos and half a dozen horses. The seasons were poor to average.

After three or four years, regeneration of silver saltbush (Atriplex bunburyana) and Gascoyne bluebush (Maireana polypitygia) had become noticeable. Records from monitoring sites he installed at the time of fencing, revealed significant regeneration. He continued to protect the area from grazing for a further three or four years.

By this time, regeneration was well advanced, and he reasoned that there were sufficient perennial plants to support his rams and provide seed for continued regeneration.

Currently, the paddock is used for four to six months of the year by 200 rams, in rotation with another paddock. His monitoring sites, along with sites installed by Agriculture Western Australia, show that under this management, the paddock is continuing to regenerate.

2. Snakewood country regenerated by cultivation and seeding

The area regenerated in this example was a 24 kilometres long, narrow paddock of Winning land system (75 square miles or 192 square kilometres in area).

The paddock had a history of stocking with about 4000 sheep. With grazing concentrated in the southern end of the paddock, where the sheep watered, severe degradation and erosion had occurred.

The flat to gently sloping plain, had once supported a very scattered tall shrubland, dominated by snakewood (Acacia xiphophylla) with an understorey of silver saltbush (Atriplex bunburyana), tall saltbush (Rhagodia eremaea) and Gascoyne bluebush (Maireana polypitygia).

On taking the station over, the incoming pastoralist targeted this paddock for remedial action. His strategy was to subdivide the paddock into three by fencing to vegetation type. He then planned to remove stock from the degraded portion and cultivate and seed with buffel grass. The remnant perennial plants, he gauged capable of spreading naturally, once spelled from the previous intense grazing pressure.

As planned, when his fencing was completed, he cultivated the more barren areas with a tine pitter, at inter-row spacings of 10 to 20 metres. He spaced the cultivation more widely on the less barren areas. Regeneration by buffel grass was noticeable after the first rains, especially in the pits.

In the absence of grazing, remnant Gascoyne bluebushes (Maireana polypitygia), cotton bushes (Ptilotus obovatus) and scrambling saltbush (Chenopodium gaudichaudianum) soon began to recolonise the area. Weeping grass (Chrysopogon jallax), Roebourne plains grass (Eragrostis xerophila) and prickly acacia (Acacia victoriae), also responded to destocking.
Once notorious for its dust storms, the area is now stable.

Currently, the pastoralist uses the regenerated southern portion (now a discrete paddock) as a ram paddock. The 400 rams are joined with the ewe flock in other paddocks and from November to April (six months), the paddock is spelled from grazing. Under this management the condition of the paddock has steadily improved, with plants taking advantage of any summer rain.

The pastoralist has regenerated other areas on the station, with a ripper he had built. His regeneration strategy is to cultivate the uppermost parts of catchments in winter, or just before seed begins to set, so that wind and water can spread seed around the cultivated areas and gradually colonise degraded areas downslope.

3. Timing of limited duration grazing regenerates shrubland pasture

In several paddocks around the shearing shed on this station, including the airstrip, control of grazing has lead to a steady natural regeneration by silver saltbush (*Atriplex bunburyana*) and three-winged bluebush (*Maireana triptera*).

Historically, sheep moved off shears into these paddocks and gradually dispersed to more remote parts of the station. This practice lead to the loss of all understorey plants from these paddocks. Remnant communities of silver saltbush and three-winged bluebush persisted in adjacent paddocks, which didn’t receive large numbers of sheep off shears.

When the pastoralist took over the station, he recognised the problem and trucked his stock off shears into their allotted paddocks. With a reduction, and in some instances elimination, of grazing, natural regeneration occurred rapidly. Seed from the remnant shrub communities in neighbouring paddocks, blew and washed into the degraded paddocks that still had intact soil surfaces.

Seeing these flat to gently sloping alluvial plains covered with shrubs, it is difficult to imagine they were ever bare.

The pastoralist considers management options based on stock control to be best for tackling degradation on a broad scale. He also places high priority on controlling the timing and duration of grazing of different vegetation types on his property.

Taking into account the growth pattern of his shrubs and grasses, his management strategy is to graze them after they have flowered, set and dropped their seed.

As a result, he has seen a steady improvement in the condition of his country and many paddocks once devoid of understorey shrubs are now revegetated.
RECOMMENDED FURTHER READING

Fitzgerald, K. (1968). The Ord River catchment regeneration project. Bulletin No. 3599, Department of Agriculture, Western Australia.


Petheram, R.J. and Kok, B. (1983). Plants of the Kimberley Region of Western Australia. University of Western Australia Press.


Logistical support

1. Tools and equipment

To minimise cost per hectare it is necessary to maximise efficiency i.e. reduce maintenance and repair time. To achieve this reduction the machinery operator has to have the right gear to carry out preventative maintenance and effect speedy repairs.

A suggested minimum tools and equipment list appear below:

(a) Puncture repair kit

(b) Hand tools and associated items

2. Fuel, oil and lubricants (FOL) trailer

A special purpose trailer facilitates the rapid refuelling and daily maintenance required by regeneration machinery. This trailer may also house the tools and equipment together with spare parts and consumables (e.g. ripper tips, shear bolts).

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item description</th>
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<tbody>
<tr>
<td>1</td>
<td>Bead breaker</td>
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<tr>
<td>2</td>
<td>600 mm tyre lever</td>
</tr>
<tr>
<td>1</td>
<td>Valve tool</td>
</tr>
<tr>
<td></td>
<td>Tube patches/vulcanising glue</td>
</tr>
<tr>
<td>2</td>
<td>Crisscross tyre casing patches</td>
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<td>10</td>
<td>Tyre valve</td>
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<td>1</td>
<td>Air compressor</td>
</tr>
<tr>
<td>1</td>
<td>3 tonne hydraulic jack</td>
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<tr>
<td>1</td>
<td>Rubber hammer</td>
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</table>

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<tr>
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<td>Set</td>
<td>Ring Spanners</td>
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<tr>
<td>Set</td>
<td>Open ended spanners {3/8&quot; - 1&quot; AF or metric equivalent</td>
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<tr>
<td>Set</td>
<td>Socket spanners</td>
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<tr>
<td>Set</td>
<td>Screw drivers</td>
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<td>1</td>
<td>450 mm adjustable spanner</td>
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<td>Set</td>
<td>Steel punches</td>
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<tr>
<td>Set</td>
<td>Socket spanners (3/4&quot; drive)</td>
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<td></td>
<td>(1 1/6&quot; - 1 1/2&quot; AF in 1/16&quot; intervals)</td>
</tr>
<tr>
<td>1</td>
<td>Socket ratchet (3/4&quot; drive)</td>
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<tr>
<td>1</td>
<td>8&quot; socket extension (3/4&quot; drive)</td>
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<td>1</td>
<td>Hammer</td>
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<td>1</td>
<td>Grease gun</td>
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<tr>
<td>-</td>
<td>Lockable tool boxes (steel)</td>
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