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Restoring degraded rangelands

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Introduction
Desertification of the world's rangelands is a problem of immense proportions. It is of profound importance to present and future generations of Australians.

The vegetation in arid environments has been subject to grazing by domesticated animals in most pastoral regions throughout the world. Almost invariably this has led to overuse, pasture degradation, reduced productivity, accelerated rainfall run-off, increased erosion and, in extreme cases, the formation of deserts.

Regenerating such degraded and eroded pastoral country in low rainfall areas is a slow and costly process even under the best of conditions. If much top soil has been lost, the problem becomes even more complex and more expensive to treat effectively. In many cases top soil conditions must be improved before vegetation can be re-established... yet another slow and difficult process. Even then, regeneration on the treated soil must proceed through a gradual plant succession from 'pioneer' annual species through to the permanent and more productive perennial species needed for a stable pasture.

There are no quick, cheap methods of revegetating badly degraded and seriously eroded pastoral country. But there are effective methods of preventing further pasture damage and of reversing the downward trend in range condition, either through grazing manipulation and/or cultural operations and reseeding.

Range management
Most pastoral lands fall within the area defined as the 'arid zone', where rainfall is usually inadequate for plants with the capacity to withstand heavy and continuous grazing. Rainfall often varies in both quantity and occurrence. Only the hardiest of perennials persist under these conditions. When subjected to continuous over-grazing they are likely to disappear, particularly in less favourable seasons. Annual plants which replace them are poor substitutes for perennials. They can provide a wealth of useful material in good seasons, but are lacking in dry years. Nor do they afford much protection to the soil in dry years when this is needed most.

Stability of the vegetation an arid grazing ecosystem is determined mostly by the resistance of the dominant plant species to grazing, trampling, drought and fire. Good range management aims at maintaining a productive equilibrium between soils, water, plants and animals.

Australian situation
Considerable evidence accumulated by research workers throughout the arid and semi-arid areas of Australia has confirmed that many land types have been degraded seriously. The conclusion from all these studies in marginal rainfall areas is that the major cause of pasture degradation, reduced productivity and subsequent erosion is the excessive removal of vegetative cover by consistent and continuous overgrazing by both domestic stock and vermin. The effects of fire and periods of drought aggravate an already precarious situation.

Often pastoralists are unwilling to forego immediate returns from their land in favour of long term projects to restore its productivity. Often, land administrators are reluctant to enact unpopular legislation to protect pastoral lands. Range ecologists, despite their knowledge, usually lack the authority to enforce controls they know should be beneficial in the long term.

If proper management objectives are to be achieved, one must know something about the nature of the resources, its present condition, and be able to assess the changes induced by management decisions.

Range inventory surveys, and rapid but accurate methods of assessing range condition trends, are essential features of a successful range regeneration programme.

Range condition is the vigour, health and status of a particular piece of country at a given time, while range trend is defined as the change in that condition over time. The trend in range condition is the direct result of the management decisions taken for a section of rangeland. One can judge the effects of past management practises by analysing this trend.

Range regeneration-methods of approach
In any regeneration programme remedial action is directed towards treating the basic cause—the removal of vegetative cover. Grazing control and the regulation of seasonal use and stocking rate are first requirements. Fences and watering points must be available to make this possible. Many Australian pastoral properties are well supplied with bores equipped with windmills or engine-driven pumps. Some degree of stock control is possible by manipulating such supplies, but watering points such as springs, flowing bores and rivers are almost impossible to use for this purpose.

In most regeneration work, grazing manipulation, involving periodic spelling or deferment, is usually enough to ensure re-establishment of perennial grass species. It is certainly the cheapest method and the easiest to implement.

Range management
Although there is no general consensus on the best management system for arid pastoral area conditions, most range research workers agree on the need for conservative stocking rates. Some suggest that a deferred rotational system is a beneficial way to use rangelands for the long term preservation of the resource, and claim it is easy to apply if paddocks are available.

H. Suijendorp (1969) has clearly demonstrated the value of 'deferred grazing' as a means of regenerating degraded and spinifex-dominated pastures in the Pilbara region of...
Western Australia. The return of edible perennial grass species has been promoted by deferred grazing, coupled with judicious dry season burning of the spinifex.

There is an important difference between spelling and deferment. Whereas spelling infers freedom or protection from grazing for a period of time, deferment involves regular spelling at a particular time... usually, the growing season. This permits the build up of seed supplies of both annual and perennial species. For perennials it also permits stems and leaves to grow and valuable root reserves, essential for the survival and carry-over to future seasons, to accumulate. In a deferment system, controlled grazing is permitted and even encouraged after seed fall as it helps to disperse and bury seed.

Uncontrolled fires can cause serious damage to pastures and can precipitate a rapid deterioration in range condition. They can promote undesirable, and unpalatable plant species. However, fire can be a valuable management tool in particular situations and if used at the right time of the year. It can be used to regulate undesirable plants and remove coarse unpalatable material. It should be used with caution on most perennial grasslands.

If soil degradation and erosion are well advanced, grazing manipulation is often inadequate, so cultural operations are necessary. This applies particularly if soils are compacted, glazed and impervious to moisture.

The Gascoyne River and Ord River catchments are two major catchment areas in Western Australia which both suffered from long periods of over-grazing and are now undergoing remedial treatment. They illustrate two different approaches to the management and regeneration of degraded catchments or pastoral country.

Gascoyne catchment

The Gascoyne River catchment in the north west of Western Australia covers an area of approximately 17,000 sq. km. It has a long history of continuous grazing by sheep and more recently by cattle, under marginal rainfall conditions. The annual rainfall of about 200 mm is erratic and unreliable. Often, it is associated with heavy cyclonic downpours in summer when temperatures and evaporation rates are high. Winter rains, when they occur, promote growth more effectively than the summer falls because of lower temperatures and less evaporation.

Excessive runoff from the Gascoyne River catchment caused severe flooding on plantations and in the coastal township of Carnarvon in 1961. Ground and aerial surveys of the catchment confirmed the extent of pasture degradation and accompanying soil erosion and indicated the need for regenerative treatment, (Lightfoot, L.C., 1961).

The Gascoyne Erosion Committee set up by the Pastoral Board recommended in June 1969 that a joint survey team consisting of officers of the Departments of Agriculture and Lands and Surveys be set up to examine in detail and report on the vegetation and erosion status of the catchment.

After a detailed study, the survey team made recommendations on stocking rates and remedial treatments for each identified rangeland type.

Of the total catchment area, about 9,300 square kilometres were found to be so eroded that they could be damaged irreversibly unless grazing ceased. A further 33,200 sq. km were degraded and partly eroded. This area required careful management to prevent further degradation. Some 20,500 sq. km, composed mainly of hill or stony short grass country, were in acceptable condition. The remaining 8,000 sq. km were in good condition and not eroding.

The team recommended that sheep numbers be reduced from the then 416,800 to about 239,000 to prevent further erosion and to assist in catchment rehabilitation. It recommended that continuous grazing be avoided, particularly after severe drought years and in degraded and eroded situations.

Since then, a follow-up committee has been appointed to seek ways to implement the recommendations on a station-by-station basis. It comprises an experienced officer from each of the Agriculture and Lands and Surveys Departments and the manager or owner of the property under review.

The regeneration of the Gascoyne catchment will be a slow process, needing careful monitoring of the regenerating pastures. Aerial photography provides a very useful tool for measuring any "trend" in pasture condition changes. Fixed monitoring sites and permanently marked flight lines are established. After mapping and recordings to establish ground checking data, the sites are photographed from a low flying aircraft at suitable intervals to assess changes in range condition. Flight lines are laid out to a set design and outlined with old motor tyres painted white for easy location. Once permanently located the flight lines can be flown and photographed as required to assess the effects of management on the condition of the pastures.

Over the past three years the researchers have been evaluating satellite photographs as a potential tool for monitoring trends in range conditions. Indications are that in the longer term and with improved methods of data interpretation this technique could become a valuable method of range evaluation. Its advantages are its repeatability and capacity to cover the vast areas associated with pastoral country.

The Gascoyne River catchment regenerative programme is dependent on cooperation with pastoralists. It uses the generally accepted and less expensive methods of regeneration through grazing manipulation, control and regulation.

Ord River Catchment

A different approach has been adopted in the East Kimberley region where it was necessary to resume areas of pastoral lease, then follow up with cultural operations and reseeding.
Severe erosion of the Ord River catchment area posed a potential situation threat to the then-proposed main dam of the Ord River Irrigation Project where engineers calculated the silt load of the river to be about 20 million tonnes a year.

The regeneration project aims at treating and revegetating this vast area of bare, degraded and eroding country in the Ord River catchment area, in an effort to stabilise the country, prevent further erosion, reduce the silt load of the rivers and restore productivity to degraded pastoral lands.

This project is probably the biggest of its kind ever undertaken in Australia and possibly in the world. Of the 46,000 sq. km of catchment an estimated 4,800 sq. km were subject to severe erosion when the project started. The eroded area lies astride the Ord River and its major tributaries the Elvire, Negri, Stirling, Panton, Turner, Nicholson and RB rivers. The bulk of the eroded country lies in Western Australia but part projects into the Northern Territory.

The erosion-susceptible areas were defined in a Lands Department survey in 1944 by Teakle and Metcalfe, and described in detail in a CSIRO Land Research Survey in 1952. Aerial reconnaissance in 1962 by Fitzgerald and Suijdendorp of the Western Australian Department of Agriculture confirmed that most of the erosion was confined to fine-textured calcareous soils formed from Upper Cambrian limestone, siltstone and mudstone. These are prone to wind and water erosion. Originally they supported grassland or grass savannah woodland vegetation dominated by perennial grass species.

The area’s average annual rainfall is between 425 and 450 mm. It falls in summer, mostly as heavy downpours followed by long dry spells.

The East Kimberley region was settled between 1882 and 1886...among the earliest selected for cattle raising. It has been subjected to heavy grazing pressure since then. Eighty to 90 years of continuous open range grazing, based on natural waters, has devastated this formerly productive country.

Gully and sheet erosion were widespread and severe. Severe wind and water erosion occur, but water has caused the most spectacular damage. Many land gullies four to five metres deep obviously originated as cattle pads where stock made their way down to river pools to water. Wind and water have cut and scoured the surface, leaving an exposed subsoil of reduced fertility, or a hard, sealed almost impervious surface. Under these conditions plant establishment is difficult even after good rains.

**Grazing control**

Grazing control in the affected area was the first remedial requirement, so the Department of Agriculture undertook a large-scale fencing programme. About 1,000 km of cattle fence was constructed, dividing the area into 18 large paddocks. Thus progressive destocking was possible before cultural treatment started.

Early experience confirmed that soil moisture was limiting because of poor penetration and seed supplies exhausted. Some of the area had been bare and windswept for 20 to 25 years before the regeneration project started. On bare and compacted soils, infiltration rates as measured by a standard single rim infiltrometer were only 3 to 4 cm per hour. Rain falling on these soils failed to penetrate, and runoff was almost complete. By removing the surface crust of approximately 1 to 2 cm, infiltration rates were increased to 12 to 15 cm per hour. Breaking the soil with a chisel plough greatly improved water penetration rates.

**Cultivation**

Cultural operations aimed at increasing water penetration, providing a seedbed and reducing wind velocity at ground level. A rough cloddy seedbed proved better than a fine one, which quickly resets.

Due to the bare nature of the soil, the excessive runoff, the degree of slope and heavy falls of rain, all cultural operations and reseeding were done on the contour. All strips were made discontinuous so that water could not flow along long furrows and cause gully ing.

In practice the cultivating machine was held in the ground for about 20 metres and then lifted out for about six to seven metres. Each successive row covered the gap above and below it. This system, still in use, greatly increases water penetration by holding water on the slopes for a longer period and permits surplus water to escape, but at a reduced velocity. The distance between furrows can be varied with location and the degree of slope but spacings of five to six metres have proved effective.

Conventional surveying of contour lines proved time-consuming and expensive, so a tractor or vehicle-mounted modified hose level was developed to speed up the work. With a little practice these can be operated at about 6 to 8 km/hr with an acceptable degree of accuracy. Mounted hose levels are satisfactory for large-scale regeneration work but are not recommended for operations where a high degree of accuracy is required.

**Reseeding**

In any regeneration programme the re-establishment of native perennial species is highly desirable but, at the Ord River catchment, natural seed supplies had been depleted from the bare area. Reseeding with introduced perennial species was necessary. Buffel and Birdwood grasses (Cenchrus sp.) and kapok bush (Aerva javanica) were selected because they were available in large...
The stark pattern created on the denuded catchment by the cultivation and seeding implements.

A wide range of cultural implements for regeneration work is now available, having been developed, tested and modified to suit local conditions. An opposed-disc plough, quantities at a reasonable cost. All three types had been grown experimentally on the catchment before the major project began, and had proved their ability to grow and spread under harsh conditions.

A typical Ord catchment erosion gully. Note kapok bush colonising the area.
developed for this type of work, has proved most effective on hard ground, while a five or seven-pronged chisel plough is useful also. When used in combination the bank formed by the opposed disc plough tends to pond the water while the chisel plough working on the up-slope side increases water penetration and provides a good seedbed.

The stability of the banks produced by an opposed-disc plough can be improved by mounting a single ripper centrally between the opposed discs to fracture the ground slightly ahead of the them. The loose soil comprising the banks tends to settle after rain and merges with the ripped soil to give greater bank stability.

An opposed-disc pitter developed at the Ord River project has shown promise. It is effective on hard ground and produces a discontinuous pattern, thus eliminating the need for working on the contour. On areas still carrying some annual grass cover, the pits remain effective for four or five seasons.

There is ample scope for developing other machines capable of handling the confined spaces between gullies or among gully heads where chisel or opposed disc ploughs cannot operate. In such places a non-directional type of cultivation is necessary, otherwise further gullying can be encouraged.

A spiked roller, used for this purpose, punches holes into the ground where seed and water can collect, encouraging plant establishment between the original cultivated strips and among the gully heads.

Cultivation and reseeding have been done in one operation with a seedbox mounted on the back of the tractor, or on an implement, and chain driven from a sprocket on the rear tractor wheel. A ground wheel can be incorporated to drive the seeding mechanism but this can be troublesome on uneven ground. A recent innovation is to operate the feed mechanism hydraulically from the tractor hydraulic system.

The purpose of the original cultivation has been to cover the widest possible area to establish plants from which seed can spread by natural means. Follow-up work with cultivators, chisel ploughs or spiked rollers working between the earlier contour lines enhances this spread.

For economy and speed of operation, rubber-tyred tractors of 26 kw to 49 kw capacity with matching equipment on three-point linkage control have been used almost exclusively. Heavy crawler tractors and graders were used experimentally on selected sites to test the effectiveness of heavier banks. However, large structures were avoided in the general rehabilitation programme on the Ord because of their high costs.

**Aerial seeding**

Aerial seeding was tried but proved ineffective on completely bare and severely degraded areas of the Ord River catchment. Because there was no seedbed, most of the seed blew away. However, this technique could have a place on cultivated areas, or as a means of introducing desirable species into established annual vegetation . . . though such annuals can compete so strongly that they reduce its worth.

A broad-scale approach which combines progressive fencing, grazing control and pasture re-establishment is necessary to reduce run off and halt active sheet erosion before even the smaller gully heads can be stabilised with vegetation. The bigger gullies will be a lot more difficult to deal with. Erosion is widening their walls continually. Eventually they will fall in and round off by natural processes.

The successful re-establishment of perennial vegetation on a vast area of formerly bare or badly degraded Ord River catchment is a major achievement. Protection from grazing, cultivation and reseeding aided by favourable seasons contributed to this success.

Controlled grazing trials have been started to determine whether the regenerated pastures can be restocked safely under stringent long-term control.

**Management needs**

Six essential features of catchment management emerge from the Gascoyne and Ord River catchment work:

- The need for a policy of conservative stocking, coupled with a programme of periodic spelling.
- The need for fenced and watered areas where livestock can be controlled; alternatively, control of water supplies to discourage grazing.
- The need for a method of range assessment which will supply vital information about the current condition of the resource, and the ability to define trends accurately and quantitatively so that management decisions which take seasonal conditions into account can be made without undue waste of time.
- The authority, if needed, to enforce unpopular but necessary management decisions designed to preserve catchment stability and ensure future productivity. Such compulsion rarely would be necessary because most pastoralists are vitally interested in the condition and long-term productivity of their leases.
- The need for adequate finance, technical skills, suitable seed and equipment to carry out any necessary remedial work.
- The need for understanding, goodwill and co-operative effort between Government agencies, landowners and pastoral lessees.

**References**


