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Restoration of degraded grazing country in the semi-arid areas of NSW

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Background

The semi-arid region of NSW was settled in 1870, with wool production being the major focus. From settlement through to 1950, and even later in some places, rabbits were a major cause of degradation. During this period there were numerous droughts and the land suffered degrees of overgrazing from both domestic and non-domestic animals. In some areas valuable perennial species were lost and livestock production is now reliant on production from annual species.

While annuals can provide a greater bulk of production in good seasons, they are less able to exploit subsoil moisture or utilise small, out of season rainfalls, and they require relatively large opening rains to initiate growth each year. As a result, long-term production has declined and it is desirable to increase the proportion of perennials in the pasture to increase livestock production as well as environmental stability. This process will be a long-term project.

This Primefact sets out a procedure to assist in the restoration of our degraded rangelands.

Introduction

In western NSW, livestock are run at low densities in large paddocks. The paddocks usually contain many vegetation types that are important for livestock production as well as environmental stability.

Livestock by their very nature will favour the more palatable species within a paddock which may result in less palatable species becoming dominant. In many areas set stocking combined with higher stock densities has contributed to vegetation change and land degradation.

Semi-arid areas of NSW are hot and dry and as a result natural processes have evolved which make full use of rain whenever it falls. Natural processes concentrate nutrients, seed and water into 'fertile patches' that are essential for a healthy landscape.

Areas suffering from prolonged vegetation decline are likely to have limited numbers of desirable plants to provide seed. These remnants are important for regeneration, making their efficient use critical in any restoration project.

For restoration projects to be successful the following areas need to be addressed in priority order:

1. Grazing management
2. Natural processes
3. Introducing seed.

1. Grazing management

The first step in any project is to ensure that grazing is managed well to reduce the risk of further degradation.

In the past, set stocking has been the most common way to manage grazing. In some instances at very low stock densities this practice has been successful at maintaining but generally not improving rangeland condition. Set stocking at higher stock densities has commonly resulted in a decline in the most palatable perennial species and an increase in less favourable species.

The second step is to realise that timely grazing management can have a positive impact on rangeland condition (see Figure 1).

Figure 1. A healthy Belah Rosewood community, with a good grass-based pasture sward [Photo: Steve Clipperton]

'Tactical grazing' is a concept which combines positive outcomes for both vegetation and animal production. It involves setting paddock objectives and developing strategies to achieve them and implementing those strategies tactically in response to changing seasonal conditions.

The most common objective is to encourage palatable, productive perennials, as they are good for animal performance and, just as importantly, they help to maintain a healthy environment (see Table 1 for such desirable plants).

The concept of tactical grazing is discussed further in *Best Management Practices for Extensive Grazing Enterprises*. It cannot be described in terms of simple recipes as the appropriate strategy will depend on the condition of individual paddocks and their capacity to respond to management. However, some important considerations are discussed below.

1. **Assess the paddock for the general health of vegetation and soil (natural processes) and the type and quantity of palatable, productive perennials.** Table 1 lists pasture species that have the greatest potential for production and restoration and two important examples are shown in Figure 2. Assess the paddock's capacity to respond to management in a reasonable time frame. (Refer reference list: *Glove Box Guide to Plants of the NSW Rangelands*).
2. **Develop achievable objectives.** If the density of a desirable species is too low to begin with, grazing management alone will not be enough to increase density to an adequate level. In this case, grazing management combined with seed introduction will be required. There is limited information regarding favourable plant densities. In most cases you will need to use your observations of healthy pastures to guide you.
3. **Develop a grazing strategy for the paddock to promote desirable plants and retard undesirable plants.** This will involve either spelling or heavily grazing paddocks at key times. To do this, larger mob sizes are required. Boxing mobs together allows paddocks to be spelled at key times. It may also allow greater grazing pressure to be placed on undesirable species, although the capacity for this needs to be assessed in specific situations. The potential downsides of tactical grazing are increased mustering for paddock changes and potentially a greater concentration of kangaroos in un-grazed paddocks. This however may be positive in a kangaroo control program. On the other hand, having stock in fewer paddocks can considerably reduce operating costs e.g. by reducing the length of water runs. (Refer reference list: *Glove Box Guide to Growth, Flowering, and Seeding of Plants of NSW Rangelands*).
4. **Control grazing in different vegetation types.** Where practical, realign or erect new fences to restrict or promote separate grazing of vegetation types. In some instances it may be possible to control grazing by restricting access to watering points at the appropriate time of the year.
5. **Aim to maintain ground cover at a minimum of 40%**. Ground cover includes plant butts, biological soil crusts, litter and other organic material. Maintaining ground cover helps to protect soil from erosion as well as providing protection for seed germination.
6. **Aim not to utilise more than 30% of the growth of perennial grasses.** As a general guide, 30% utilisation of grasses equates to a plant height of around 15 cm. Tactical grazing to achieve 30% utilisation improves the ability of perennials to survive drought. This assumes that in some years grasses will be grazed more heavily but allowed to recover and set seed in the following year (see Figure 3. Utilisation level photo standards).
7. **Replenish seed reserves by allowing desirable plants to fully set seed every few years.** Annual species rely on seed reserves to survive, so it is important to ensure they are grazed carefully to ensure sufficient annual seed set. It is also important to allow perennial grasses to fully set seed every 3–4 years. This maintains seed reserves as well as allowing maximum root reserves.

8. **Allow perennial grasses to grow and develop an effective root system.** As a general guide root mass is similar to above-ground plant mass. If perennial plants are grazed too early before they have developed an adequate root system, they are more likely to be pulled out when grazed. They are also less able to survive dry periods as they cannot access moisture from further down the soil profile.
9. **Productivity is likely to be greater and more stable in diverse grasslands.** If introducing seed, consider using several local species, ideally with different growth characteristics such as cool season and warm season growth periods (refer Table 1). Diverse grasslands not only provide ideal conditions for bio-diversity but also provide increased animal performance because of their wider growth period. They are more likely to have species growing throughout the year due to seasonal growth habits and their ability to take advantage of small rainfall events. If considering introducing exotic species such as buffel grass, be aware that it may become dominant and reduce diversity.
10. **Tactical management involves monitoring.** Continually monitor vegetation and soil conditions, and use stocking rate records combined with seasonal conditions and longer term weather forecasts to adjust stocking rates to achieve objectives (refer reference list: *Best Management Practices for Extensive Grazing Enterprises*).
11. **Be prepared to reassess paddock management objectives.** Paddock management objectives are not set in concrete and can change as the original objective is achieved or seasonal conditions provide unexpected opportunities.

Figure 2. Palatable, productive perennial grasses – mulga Mitchell (left) and mulga oats (right). [Photo: Tony Grice]

Table 1. Desirable native perennial grasses found in western NSW.

Species	Distribution	Notes on growth patterns	Notes on grazing
Curly Mitchell grass *Astrebla lappacea*	Widespread on clay soils of floodplains, and desert loams of the Barrier and Grey Ranges	Long-lived (30 years); flowers 4–6 weeks following heavy summer rainfall; recruits infrequently	Palatable when young; will tolerate moderate grazing; susceptible when grazed below 20 cm; drought tolerant
Wallaby grass or white-top *Austrodanthonia caespitosa*	Most abundant on clay soils of Riverine Plain in the south	A cool season species flowering in spring/early summer and occasionally in autumn; recruits readily	Highly palatable, tolerates only moderate grazing
Windmill grass *Chloris truncata* (Note: can behave like an annual)	Widespread throughout the region	Grows throughout the warmer months; good coloniser of eroded soils; flowering in response to spring/summer or autumn rainfall	Moderately palatable; tolerates moderate grazing; generally intolerant of frosts
Queensland bluegrass *Dichanthium sericeum*	Widespread throughout the region except the southern third; most frequent on clay soils; often found on run-on areas	Flowers in response to summer rainfall; tends to produce green feed in early spring/summer; recruits readily	Palatable, particularly to cattle; can become tall and rank; susceptible to drought
Silky umbrella grass Finger panic grass *Digitaria ammophila* *Digitaria coenicola*	Scattered throughout the northern half, sporadic in southern districts; sandy or loamy red earth or duplex soils, often in bimble box or mulga communities	Flowering mainly summer; summer growing; dormant in winter	Highly palatable, grazed in preference to many other perennial grasses; quite drought resistant
Common bottlewashers *Enneapogon avenaceus* (annual species, but can persist if seasons are good)	Widespread in western half of the region, less common in east; prefers sandier soils	Flowers in summer–autumn; will recruit readily in wet summers; can be eliminated by overgrazing when seed is being set	Highly palatable at all stages; relatively small contribution to pasture
Curly windmill grass *Enteropogon acicularis*	Widespread throughout the region; less frequent in north-west; on all soil types from sandy loams to clays	Flowers mainly in spring–autumn; long-lived; recruits infrequently	Moderately palatable when young; will tolerate moderate grazing and drought; eliminated by heavy grazing
Woolly butt *Eragrostis eriopoda*	Northern half of region, extends south as far as Pooncarie; sandplain areas with deep, often calcareous sandy red earth soils	Flowering mainly autumn	Low to moderate palatability; extremely hardy; advantage is as stabiliser of soil and other vegetation
Neverfail *Eragrostis setifolia*	Widespread throughout the region, less frequent in south and central-east; most common on clayey soils, gilgais, creek floodouts, silt traps of tanks, margins of swamps	Flowering throughout year, most commonly in spring and autumn	Highly palatable; can withstand severe grazing; persistent
Bandicoot grass Mulga oats *Monochather paradoxa*	Mainly in the northern half, on sandplains and dunefields in the west, and slopes of hills and ridges in the east	Tends to flower throughout the year in response to rainfall	Highly palatable, will tolerate only moderate grazing; drought resistant
Native millet *Panicum decompositum*	Throughout the region; mainly clay soils in depressions and gilgais on floodplains; also red earth soils, clay and duplex soils	Flowering summer–autumn	Important and reliable summer forage producer on floodplains; suspected of poisoning stock; can withstand heavy grazing
Box grass *Paspalidium constrictum*	Widespread throughout the region, less frequent in south-west; often found where soil moisture and nutrients are high; under trees, protected by branches; not found on grey clay soils	Flowers in response to summer rainfall; regenerates rapidly following exclusion of stock	Highly palatable species that is also drought tolerant; green pick for sheep in all but driest times
Kangaroo grass *Themeda australis*	Widespread throughout the region, except in south-west; usually red and red brown soils, often in drainage lines	Flowering mostly spring–summer; mainly grows in spring and summer	Younger plants attractive to stock; palatability and nutritional value vary; does not withstand continuous heavy grazing
Mulga Mitchell grass *Thyridolepis mitchelliana*	Widely distributed north of line from Broken Hill to Griffith; red earth soils on sandplains, flats and stony ridges	Mainly spring–autumn; warm season grower; can also provide green feed in moderate winters	Highly palatable; withstands grazing moderately well, lost under prolonged heavy grazing

Much of this material was compiled from Cunningham, GM, Mulham, WE, Milthorpe, PL & Leigh, JH (1981), *Plants of Western New South Wales*, Soil Conservation Service of NSW; and Brooke, G & McGarva L (1998), *The Glove Box Guide to Plants of the NSW Rangelands*, NSW Agriculture.

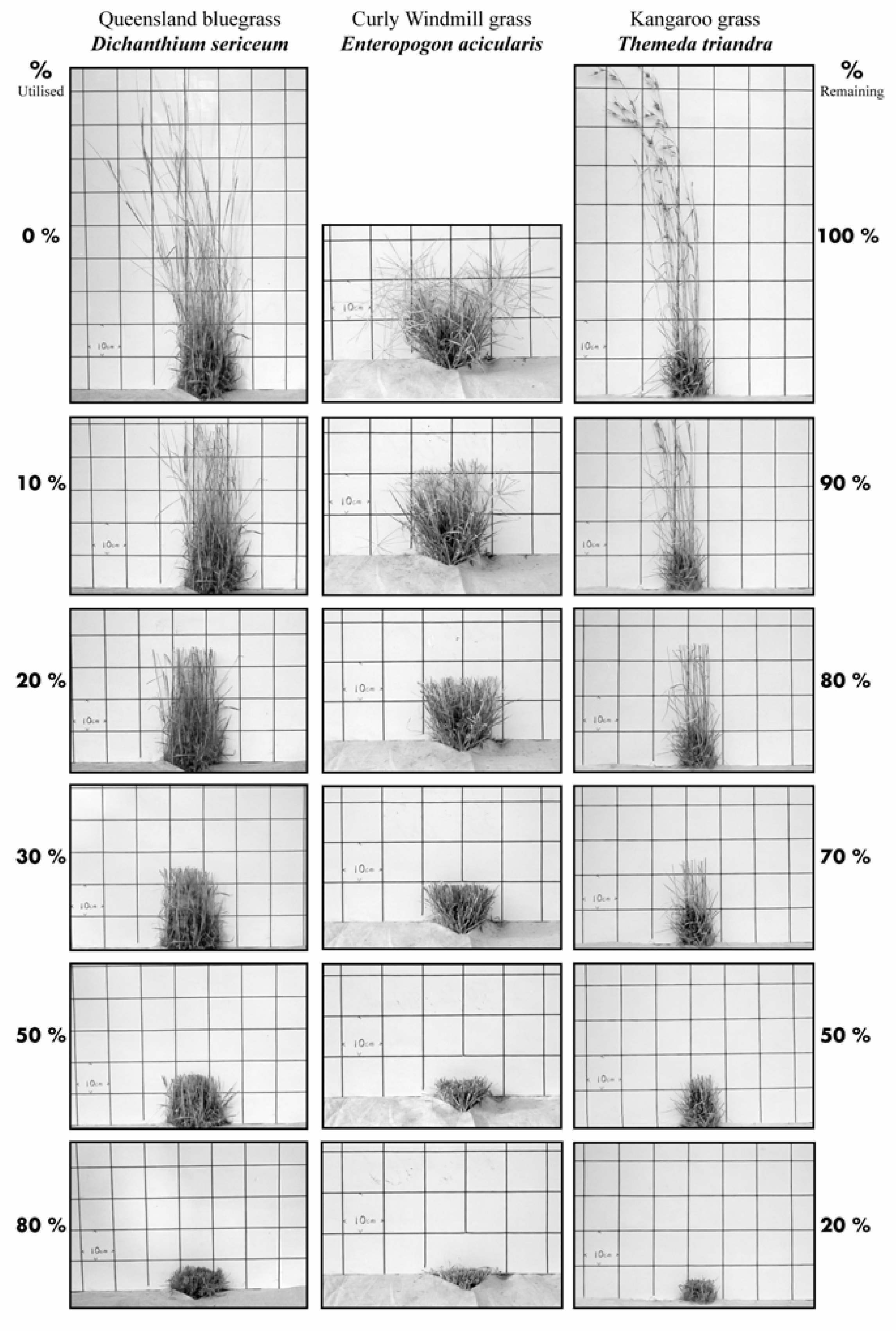
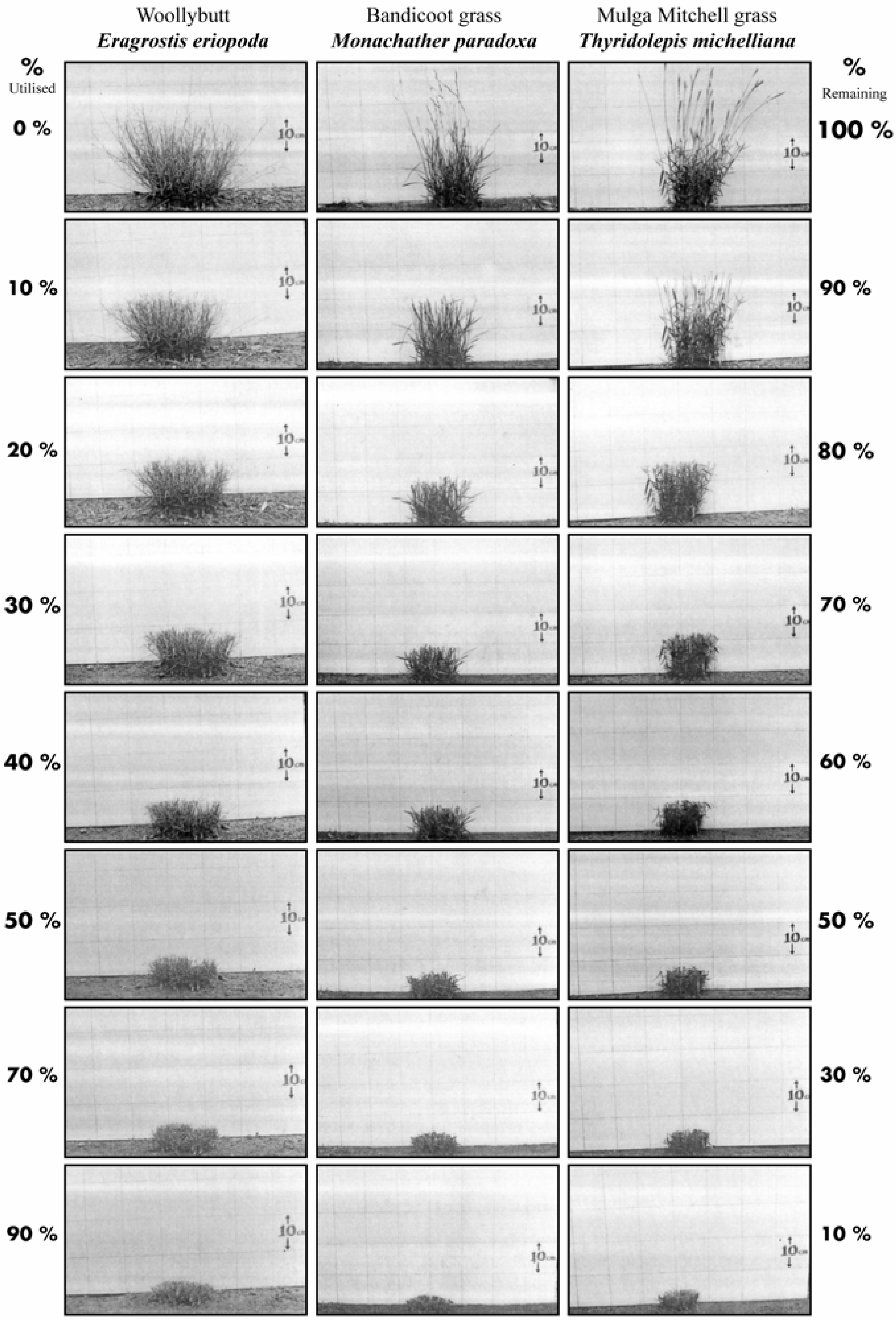


Figure 3. Utilisation level photo standards



(Source: Anderson et al. 1994)

Figure 3 (cont). Utilisation level photo standards

2. Natural processes

For long-term success of any restoration program it is important to focus on how the landscape is functioning. In a well functioning landscape the natural processes provide ideal habitats for regeneration. In such a case tactical grazing and the introduction of seed from desirable palatable, productive perennials may be all that is required. However, where the landscape is functioning poorly, further action such as developing ‘fertile patches’ may be required to ensure long-term restoration.

Landscape function refers to how effectively the landscape conserves and makes available the essential resources for plant growth, especially water but also nutrients. Effective landscapes conserve these resources within the local system, as ‘fertile patches’, while dysfunctional or leaky landscapes allow excessive amounts to escape through run-off.

For example, Mulga country on hard red soils often displays a ‘band’ or ‘grove’ arrangement of vegetation. This country requires a proportion of the area to consist of fertile patches and ‘run-off’ areas to function effectively. Slopes with low infiltration rates and few or no obstructions to slow or prevent movement of resources make ideal run-off areas. Nutrients are lost from these areas and accumulate in fertile patches or ‘run-on’ areas. This concentration of resources in fertile patches facilitates germination and survival of vegetation in sufficient quantities to provide useful feed for livestock.

In other landscapes, smaller ‘run-on’ areas scattered across the landscape may capture water and nutrients more efficiently. Where landscapes are degraded, fertile patches and seed banks may need to be developed to help them work effectively.

Understanding that this is the way that arid landscapes function allows us to harness this natural process to achieve regeneration.

Harnessing natural processes

Harnessing natural processes is one of the most cost-effective ways to revegetate rangeland areas. Inputs of capital and labour are reduced and the need to source seed is removed. There is also an increase in biodiversity and greater chance of long-term success. Natural processes ‘do the work for you’.

The concept is based on seed production areas or a ‘seed bank’ supplying seed, which is dispersed around a paddock at no cost by a combination of wind, water and animals. Water and nutrients are captured and concentrated in fertile patches of natural vegetation, where plants can germinate and grow.

To create a fertile patch, branches can be laid across a slope (see Figure 4) or the soil can be physically manipulated using mechanical intervention, for example a ‘crocodile seeder’ (Figure 7).

Anecdotal evidence suggests that cattle can place footprints in the soil after favourable rain similar to the ‘crocodile seeder’. Success with livestock relies on sufficient rainfall to soften the ground adequately to allow animals to sink and make a substantial depression.

Figure 4. Germination of plants concentrated under tree branches [Photo: Alison Rowlands].

On degraded hard red mulga country much of the water, seed and nutrients are lost through the action of wind and water. When developing fertile patches it is important that fine branches make contact with the soil surface, so that seed, fine sediment and organic matter can accumulate on the up-slope side of each small branch.

Mulga branches that have been cut for drought feeding and left lying on the ground provide an excellent site for grass regeneration.

It is not advisable to mechanically push shrubs, especially turpentine. If the roots are left exposed, re-sprouting is likely, leading to increased woody shrub encroachment. Cutting branches with an axe or chainsaw is effective and does not increase the number of shrubs.

A similar method of placing shrub branches on the soil surface should work on hard massive soils in other country types. On more sandy porous soils where much of the water sinks through the surface rather than running off, placing branches on the ground may only serve to protect seedlings from grazing.

Enhancing seed supply

In more degraded country, shortage of seed may limit the effectiveness of restoration efforts. To improve seed supply using natural processes, it is recommended that small seed production areas be established at strategic points. Ideal locations are small areas of rocky outcrop (see Figure 5) located at the highest points in the paddock. The area needs to be exposed to strong winds and be elevated to enable water to run in all directions. Areas with an existing population of the desirable species of grass and a small or negligible population of undesirable species are ideal.

Figure 5. A seed production area – a rocky ridge is an ideal area for seed production. The vegetation here is dominated by mulga oats and bandicoot grass. Mulga Mitchell grass is also present and undesirable species are virtually absent. [Photo: Steve Clipperton]

The seed production area is fenced to minimise grazing by large domestic and feral animals. Conventional ringlock fencing is most suitable as netting will reduce the movement of seed into the surrounding paddock.

A gate in the fence is recommended to allow stock access at key times. This may be necessary if the grasses become rank, inhibiting seed production. Grasses benefit from short periods of grazing as it stimulates growth and seed set. There is also a possibility that cattle may disperse seed in their dung; however, no work has been done on native seed.

Figure 6. A fenced seed production area on top of a low rise in mulga country. The area had been fenced approximately one year earlier. [Photo: Steve Clipperton]

Areas approximately 50 m wide straddling the top of the ridge or hill have been successful, but the ideal size is unclear. Early indications are that smaller, more frequent areas may be more successful than fewer larger areas. Seed banks are likely to have an effective seed dispersal range of only about 100 m. Match the shape of the fenced area with the shape of the ridge or hill (see Figure 6).

In general, it is a waste of time selecting an area if the number of desirable species is very low and there is limited potential to support such species. In some sites it may be necessary to add seed either by spreading on the surface or planting. Locally collected seed is preferable (see the section on 'Distribution and Sowing Seed').

Where necessary, create fertile patches using branches on the slopes outside the fence of a seed production area. Over time these patches will provide additional seed production.

Developing fertile patches mechanically

Imprints made by a crocodile seeder (Figure 8) effectively trap seed and nutrients on some types of country. In hard red mulga country these imprints enhance germination in good seasons but not nearly to the same extent as the piles of branches. Imprints cut by the crocodile seeder as it turns corners are usually deeper than those cut by the machine travelling in a straight line. The deeper imprints produce better germination and survival. The same effect could be achieved by using a single drum on the crocodile seeder set at a more acute angle (see Figure 7). In a poor season, the survival rate of the plants, and especially seedlings within the crocodile imprints was found to be variable and overall lower than under the branches.

Figure 7. Crocodile seeder showing two drums each with metal feet which cut into the surface as the machine is pulled across the area. The depth of the imprints depends on the offset of the two drums and the softness of the soil surface. [Photo: Tony Grice]

3. Introducing seed

(This section is based on *Grassed-up* by Waters et al.)

Areas suffering from prolonged vegetation decline are likely to have very limited supplies of seeds. In these instances seed needs to be introduced for regeneration projects to be successful in the short-term.

Native grasses are well adapted to the harsh environment of semi-arid areas of NSW. Many exotic species, with the exception of buffel grass, generally fail to persist due to drought or infertile soils.

Figure 8 Seedlings germinating in imprints made by the turning crocodile seeder. [Photo: Steve Clipperton]

Native grasses not only provide necessary habitat for many native animals, they provide a suitable pasture base for animal production and can perform as well as exotic species under harsh conditions. Work done in the 1980s at Walgett showed that Mitchell grass performed equally as well as exotic species such as bambatsi and purple pigeon grass in terms of production.

Selecting native grasses

All native grasses can be separated into either warm or cool season species. Warm season grasses, also known as C4 species, do most of their growing and seeding in the summer months, and produce a 4-carbon compound as the first product of photosynthesis (hence the 'C4'). Warm season grasses are better adapted to higher temperatures and higher light intensities. They are susceptible to frost and are winter dormant.

Cool season grasses, also known as C3 species, grow and seed in the cooler months (winter/spring) and produce a 3-carbon compound as the first product of photosynthesis. They are frost tolerant, provide green feed during winter, have reduced growth in summer and survive high temperatures and low rainfall by entering a drought induced dormancy. When temperatures are low and moisture not limited, growth is resumed.

Native grasses have a range of growth patterns, drought and grazing tolerances. For example, curly Mitchell grass tends to be restricted to heavy clay soil, is palatable when young and can stand moderate grazing. In comparison, Neverfail is most common on clay soils but is highly palatable and can withstand severe grazing pressure.

It is important to select species that are likely to be best adapted to the restoration site and suited to the grazing objectives. The choice and mix of species to be introduced into an area will be driven by local site conditions and species observed to be common to the local area. For example, Neverfail may be more suited to a holding paddock as it can withstand severe grazing pressure. The growth patterns and grazing requirements for a range of native grasses are given in Table 1.

The species mix will need to take into account the seasonality of rainfall for your area. Establishing a community of both cool season and warm season grasses provides the opportunity for year-round growth if seasonal conditions permit.

It is important to closely observe remnant areas with good cover of desirable vegetation and assess what is making the system function. These areas provide clues on appropriate species to introduce and can also provide a measure of revegetation success.

Sourcing seed

The native grass seeds industry is in its infancy with few available varieties. As a result, the market relies heavily upon opportunistic harvesting of seed from wild stands. This has created problems in seed quantity and quality as seed supply is determined by local seasonal conditions. Sourcing non-local seed is sometimes the only option.

Planning at least 12 months in advance of a revegetation program can help to reduce seed supply issues. Landcare groups and Greening Australia often have community seed banks to harvest/store and distribute native grass seed for local revegetation programs. The Department of Natural Resources (DNR) have brush harvesters for native grass seed collection. Some landholders have successfully used commercially available garden vacuum cleaners to harvest mature seed from individual plants. Source seed from a location that closely matches the revegetation site as it is likely to increase the chance of plant survival.

Before seed is purchased or used in a restoration program, germination percentage and purity information should be obtained. There is no point sowing seed that is incapable of producing seedlings or is full of weeds. Attention should also be given to the dormancy period and age of the seed to optimise establishment potential. Some grass species have short dormancy, while others have very long dormancy periods. This information can be obtained from seed testing laboratories and literature on the particular grass species. (Refer reference list: Waters et al *Grassed Up*).

Distributing and sowing seed

Early work on sowing of native grass seed focused on traditional pasture seeding methods that involved various degrees of seed processing. This processing involved the removal of structures surrounding the seed, as the smoother naked seed could be sown using conventional small seed boxes. More recently, technology has been developed for sowing native grass seed in its chaffy, uncleaned state commonly referred to as 'fluffy seed' (see Figure 9).

Sowing fluffy seed tends to have establishment advantages. For example, Queensland bluegrass has hygroscopic awns that assist in burying seed when it is wet. For other grasses, such as kangaroo grass, awns may also be useful in orientating the seed on the soil surface. There is also a suggestion that the husk and hairs surrounding seed may play a role in retaining moisture around the seed during germination. Anecdotal evidence suggests the husk greatly reduces the number of false germinations by preventing germination on light showers of rain.

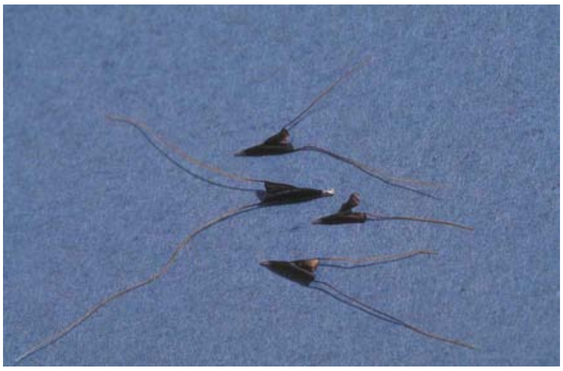


Figure 9. Windmill Grass fluffy seed. [NSW DPI photo library]

Seeders

There are few native grass species that can be sown using conventional seeders. Native grass seeds tend to clump together and clog up traditional seed boxes. Much effort has been put into designing equipment that will handle fluffy seeds or seeds with scabrid or twisted awns. There have been a number of seeders designed such as the B&S seed box, the Ausbox, the Wiedemann/Kelly seed box and the crocodile seeder (Refer to reference list: Waters et al *Grassed Up*).

Where seed treatment removes structures or renders them inoperative, the seeds must be sown at an appropriate depth for the species and conditions and close contact between the seed and the soil achieved. If seeds are to be sown onto bare soil prone to surface crusting, the soil should be cultivated first and the seed sown as soon as possible to enable sufficient burial prior to rain.

Sowing seeds in drill rows has limited applications in the rangelands. A far better approach under these circumstances is to broadcast the seed and either cover lightly using chains or harrows, or to simply rely on the ancillary structures to ensure that at least some seeds end up in safe sites. If you are considering sowing by cultivation, contact the nearest DNR office to enquire about a cultivation permit.

Crocodile seeders are one of the most commonly used mechanical means of sowing seed in the semi-arid areas (Figure 9).

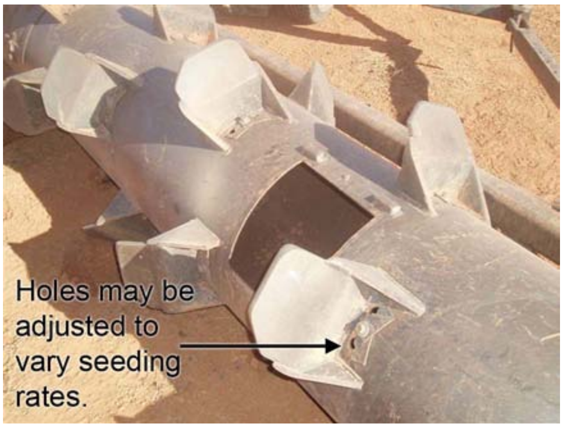


Figure 10. Crocodile drum seeder showing crude seed rate adjustment. [Photo: Paul Theakston]

When seeding, it is advisable to work on the contour wherever possible as this will retain the greatest amount of water in each of the 'pits' (Figure 11) and increase the likelihood of success.

Figure 11. Seed sown using a crocodile seeder. [Photo: Paul Theakston]

Seed blowers

Seed blowers have been designed to place seed into log mounds or fallen timber as these areas provide one of the best environments for establishment and survival of seed. These sites concentrate nutrients and moisture and protect new seedlings from drying out and being grazed. Some blowers can be mounted on 4WD vehicles. Seed is blown through a hand-held wand into suitable micro-sites while driving through a paddock (see Figure 12).

Figure 12. The Blower may be mounted on a vehicle and blows native grass seed into suitable environments for establishment. [Photo: Keith Sanders]

The Blower is constructed essentially of a bin to hold the seed, a windscreen wiper motor to move seed and a leaf blower. The leaf blower blows air past a hole in the bottom of the bin, sucking seeds out with it and blowing the seeds in the direction that you hold the outlet tube. This unit can be used mounted on the back of a ute or 4WD motor bike.

Figure 13. The Low Cost Seeder – showing internal working mechanism. [Photo: Keith Sanders].

The Low Cost Seeder (Figure 13) consists of a set of paddles that rotate seed out through a hole in one end of the unit, powered by a windscreen wiper motor. This seeder is designed to be set up on a 4WD motor bike to dribble seed on the ground in front of a bike tyre as you ride around a paddock.

Time of sowing

The seeds of many native grass species will germinate over a wide range of temperatures, although the optimum is usually higher for warm season than cool season species.

Selecting optimum sowing time depends on the rainfall distribution at the site and the species to be sown. In general, warm season species are best sown in early autumn, provided frost susceptible seedlings can become well established before the onset of winter. Waiting for spring rain has the possible disadvantage of low seedling survival in what can be high temperatures during spring. If it is possible to establish seedlings in autumn, and these seedlings survive through winter, they will be better prepared to survive the hot temperatures of spring and summer.

Seeds of cool season species will readily germinate following suitable rain in the late spring, but are unlikely to survive the first summer. These species are generally best sown in autumn.

Rate of sowing

No guidelines are available for the amount of seed that should be applied through the Blower and Low Cost Seeder. The important point is to get the seed into the niches where it will have the best chance of establishment. Seeding rates need to allow for variable germination and the reality that a significant percentage of seed will be removed by predators, especially ants.

Seed that has been laboratory tested will give an indication of seed viability, remembering that germination and survival are often lower in a field situation which relies on natural rainfall. Sowing rate is often limited by seed availability, but in general a higher sowing rate will help establish groundcover quickly and help preclude weed establishment.

There are no guidelines regarding seeding rates of native grasses using a crocodile seeder.

Keith Francisco of 'Tindarey Station' 50 km north of Cobar has 10 years experience using the crocodile seeder. He sows silk sorghum or oats as a cover crop to catch and protect wind-borne or stored native seed. He believes it is a way to recoup costs and protect the emerging native pastures. After 3 years the cover crops have gone, leaving healthy native pastures.

Keith runs the crocodile over flat country and hasn't had much experience over ridge country, although he believes results would be similar. He has observed that some pits have lasted 10 years.

Seeding rates:

- silk sorghum 5–7 kg/ha
- oats 20–25 kg/ha

He believes any more than this will result in too much competition in the individual pits.

Joe Hughes of 'Belarabon Station' 100 km south-west of Cobar has also used the crocodile for pasture establishment. He uses it to sow buffel grass and also without seed on gently sloping country to promote native grasses (Figure 14). He has had good results with native grasses germinating and surviving on little rain.

Management of seeded areas

Post sowing management is critical. If possible defer grazing until after seed set. If this is not possible, prevent grazing until plants are sufficiently anchored to the ground and do not utilise more than 30% of plant growth. This allows the plant to develop good root reserves. Remove stock to maximise seed set. Generally, perennial native grasses are well adapted to stressful environments but do not tolerate frequent defoliation. See section 1. 'Grazing Management'.

Figure 14. Crocodile seeder used without seed to promote fertile patches for existing native seed banks. [Photo: Paul Theakston]

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