2.3. How to monitor vegetation and soils

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Abstract

Many attributes could be selected when measuring and monitoring vegetation, soils and herbivores under a range of conditions, and these can be measured in a variety of ways. Each state in Australia has its own set of criteria for monitoring the vegetation resources of their grazing lands, and comprehensive packages have been developed to promote the sustainable use and management of these resources.

The pastoral industry has to take pro-active steps in monitoring the health and productivity of their pastoral lands to achieve and promote a better understanding and adoption of sustainable management practices.

This paper outlines some of the monitoring and pasture assessment techniques in Australia and describes the monitoring procedures of one of Australia's largest private landholders. It discusses important issues such as spatial and temporal variability in pastures, accuracy and precision considerations and soil condition assessments that need to be recognised in any monitoring program.

Introduction

It is easy for a grazier to stand on the edge of a paddock and look out over an expanse of knee high grass and assume everything is O.K. The memory can be a selective instrument at the best of times, and it is all too easy to view our pastures as "Good from afar" when in reality they may be "far from good".

An understanding by rangeland managers of the pasture component of their grazing system is vital to the long-term sustainability and productivity of their properties, as well as to the ecological balance and dynamics of that pasture system. The development and implementation of objective long-term pasture monitoring is vital to the all-round health of the grazing operation. We are good at judging and measuring the condition of our stock, but not so good at doing the same with our soils and pastures.

The North Australian Pastoral Company Pty Limited (NAPCO) have been monitoring pasture and range condition on their grazing operations for approximately seven years, and this is now an integral part of property management. The growing emphasis on quality control from the paddock to the plate makes demonstrating a sustainable production base essential. At the end of the day, we "market our grass as beef", to borrow a line from Harold Trollope, a South African grazier.

Background

Some rangeland managers are now taking a more objective look at the condition of their vegetation, soils and water; they are now committed to establishing some parameters to gauge the trend of the condition of these resources and establishing some benchmarks on which to base judgements. To the rangeland manager and beef producer, the need to embrace pasture management in the long-term, and to then make it relevant to animal production, is of the utmost importance.

Monitoring of pastoral lands has been identified as an important issue related to current land use in the rangelands, (Morton and Price 1994; Draft National Strategy for Rangeland Management 1996) and specific research and development activities are needed to develop suitable monitoring systems to assist the management decisions made by pastoralists. The development and implementation of a suitable and flexible monitoring system for our vegetation must be done in context with a broader plan for the paddock, the land type and the property. This monitoring procedure must then be part of the decision-making process on-property and should be reviewed regularly to determine if the management is succeeding (Olson and Burkhardt 1992).

Coping with spatial variability

Spatial variability is simply the variation of features, such as plants, soils, rainfall and grazing pressure, across an area, be it paddock, property, land unit, land system or region. Arid and semi-arid rangelands are characterised by substantial variability in rainfall, both temporally (in time) and spatially (in space) which may override management influences. Rainfall may vary in quantity per annum, seasonality, number of rain days/annum, intensity and distribution, while the interaction of rainfall variability with soil type, topography, temperature and grazing patterns produces characteristic vegetation types for the rangelands.

Friedel (1989) describes spatial variability both within monitoring sites and at the land unit scale; it may be easy to stratify monitoring sites in detail in rangeland research, but it is somewhat harder in more extensive situations.
Translating the results of monitoring into the objective assessment of carrying capacity is even harder according to Scanlan et al. (1994). There is little information on how to allow for spatial variability within a property when all land units are not grazed equally and will have different levels of utilisation.

It is important to recognise that there are many different types of monitoring systems; they are as variable as the types of rangeland upon which they are installed (Friedal 1989). At a broad spatial scale, it is difficult to locate representative sites and select suitable replicates, and only gross changes in pastures and soil composition can be detected with any degree of reliability (Friedal 1989). The location and type of monitoring site are considered later, while remembering that it is necessary to balance what is recorded at a given site, what is practical over a given area and what information should be collected to determine and interpret changes meaningfully on a production scale.

Coping with temporal variability

Temporal variability is the variation in attributes such as rainfall and pasture composition over time, and must also be taken into account when monitoring. For NAPCO, monitoring is confined to the beginning of the calendar year when perennial plants are actively growing, although monitoring later in the year could be useful to gauge effects of winter rainfall and grazing on the vegetation. Repeated monitoring in these environments should be conducted over a long period of years or possibly decades. This is particularly important on the flood-plains of the channel country, where responses in pasture condition and composition may not be seen for some time.

In practice, it is difficult to monitor vegetation at the same time each year. A delay in one or two weeks, or even a month, may influence interpretation of the results and management recommendations for that paddock or property. For example, winter rainfall that is insufficient to promote grass or herbage growth can blacken standing dry feed and reduce its nutritive value, while a wildfire may dramatically change the paddock management tactics and objectives.

An understanding of our vegetation structure and the dynamics of the system is important to the management of our grazing lands. By monitoring the condition of our vegetation resource on a regular basis, we will be in a better position to adjust our management in accordance with changing conditions in the vegetation. Smith (1979) discusses two approaches to range condition monitoring, one being an ecological approach and the other a productivity approach. Most graziers have a genuine concern for the ecological integrity of their grazing lands while at the same time having a vested interest in keeping the resource base in a healthy condition in order to return a profit from the grazing operation. It is difficult to be ‘green’ while you are ‘in the red’.

How accurate?

Techniques for rangeland monitoring should have several characteristics. They should:
- be objective
- provide useful information for decision making
- be conducted at the appropriate level of detail for management decisions
- be repeatable over time and between operators
- be adaptable to a range of situations.

Smith and Despain (1997) outlined these factors. Research may require a degree of accuracy and precision that cannot be applied as rigorously in a more extensive grazing system, but this does not mean that the methodology applied in the latter is less appropriate. Monitoring at this broader scale will detect only gross changes in the vegetation layer. The practical applicability of the assessment must be balanced against the degree of accuracy required, and accuracy is often sacrificed for speed. Inconsistencies in measurements can arise from the nature of the measurement itself, with differences between observers and from seasonal changes. However, with careful development of methodology, these inconsistencies can be minimised.

A number of destructive and non-destructive sampling methods for vegetation assessment have been described (Michalk and McFarlane, 1977; Friedel and Shaw, 1987; Catchpole and Wheeler, 1992; Despain and Smith, 1997).

Destructive sampling

Destructive sampling techniques are probably the most accurate measure of plant biomass and composition. It is, however, site-specific and the precision of the technique decreases as the spatial variation of the plant community increases; thus, it is not recommended where spatial variability is large. Destructive sampling has a relatively high cost compared to visual methods of assessment. Clipping can be impractical in dense vegetation or where large areas need to be covered, especially if the vegetation is highly variable.
Non-destructive sampling

There are a number of visual methods used for estimating plant biomass and composition. These include dry weight ranking, plant frequency sampling, comparative yield, plant basal area, step-point assessment and ground cover assessments. These techniques are subject to several kinds of error apart from the usual errors associated with sampling procedures (Morley and Clarke 1964, as cited in Michalk and McFarlane 1977). The relationship between visual estimates and true values is inconsistent among observers, pasture types and time. Observers may be influenced by past experience and complete visual assessments over a large area is impractical.

Plant frequency is defined as the number of times a plant species is present within a given number of sample quadrats of uniform size placed repeatedly across a stand of vegetation (Mueller-Dombois and Ellenberg 1974, Daubenmire 1968). Plant frequency is a function of quadrat size and reflects both plant density and dispersion. The sensitivity of frequency data to density and dispersion make frequency a useful parameter in documenting changes in plant communities (Despain et al. 1997, Smith pers. comm. 1997).

Frequency has a number of advantages: it is objective, there is no estimation or subjective evaluation necessary as it depends on presence rather than amount, and it is quick and simple.

There are also a number of disadvantages. Frequency is relatively insensitive to short-term fluctuations, but is more responsive to longer-term shifts in management. Data collected does not necessarily relate to more concrete parameters such as density, weight, height or biomass and, as frequency values are dependent on the size of the quadrat used in sampling, data collected from different sized quadrats are not comparable. Frequency is not well suited to larger shrubs due to quadrat size. Frequency can be used to indicate trends in range condition but will be more accurate when used in conjunction with additional monitoring techniques.

Ground cover can be a useful addition to plant frequency sampling. The amount of ground cover is recorded and usually consists of plant material, litter, bare ground or rocks. Ground cover can also be used to indicate trends in pastures, and can contribute significantly to the assessment of stability and production of a site.

Comparative yield is a useful measure for estimating the total yield or biomass of pastures. Pasture yield can be assessed by comparison with several known

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**GRASS Check**

Grazier Rangeland Assessment for Self-Sustainability

Second edition (revised)

Department of Natural Resources, Queensland
DNRCQ97002

Plate 2.3.1. Grass Check instructs grazing land managers how to monitor their own pastures using techniques ranging photographs to quadrats.
reference standards. New samples are then rated in terms of a range of weights. This technique can be used in conjunction with photo-standards which help increase the accuracy. This method is best suited to herbaceous vegetation and can include small shrubs, but is unsuitable for trees and large shrubs (Despain and Smith 1997).

**Photo-standards** are a useful guide to estimating plant biomass if the accuracy required is low. Weight can be determined after a number of samples have been clipped and used as references. It has a low cost, but is limited to a small area where photo-standards are developed, or for similar pasture types; new keys need to be developed for other areas and pasture types. The accuracy of this method is increased if combined with comparative yield estimates as described by Friedel and Bastin (1988).

**Estimates of biomass** are subject to large variances and inconsistencies as there is a high degree of seasonal and yearly variation. According to Despain and Smith (1997), a ‘one-off’ estimation of biomass will not measure annual production, although it may be useful to compare relative production of different pastures or communities. If production data are required, this method is as precise as most techniques and requires less training and time.

**Dry Weight Ranking** is used to estimate the species composition by weight in pastures (Mannetje and Haydock 1963, Smith and Despain 1997). It is similar to estimation of species by using a quadrat except that the observer ranks the first, second and third species by weight in each quadrat and scores the biomass for the whole quadrat. Multipliers are then used to determine the percentage contribution by weight of each species to the total biomass. This method is relatively simple and fast, and can be combined with other methods using quadrats, such as frequency.

**Basal cover** or the amount of base material from the plant that covers the ground, as opposed to aerial cover, can be used to estimate ground cover. This is usually used for grasses and tufted species. An assessment of plant basal cover for large areas is not a realistic option due to the large number of samples required.

Observer differences are critical in many assessment techniques, and, if possible, the same observer should be used for any one technique. The number of samples required to characterise a monitoring site depends on the precision required; once again, there is a balance between what is practical and the degree of sampling intensity. Sampling should continue until a specified margin of error is achieved. The precision of any technique will increase with the number of samples taken, but this in turn invokes an increase in time taken. Objectivity in measurements is greater when direct measurements are made.

While time is limited in most monitoring procedures, it should not be the prime consideration if the resulting errors render any results useless (Friedel and Shaw 1987).

After assessing various methods of herbage sampling, Friedel and Shaw (1987) concluded that none of the methods described (frequency, aerial cover and composition, weight and composition) produced reliable results when a number of observers were used. Single observers were more satisfactory for some methods. Reliability was unlikely to increase with the number of estimates and repeatability over time was likely to be poor. For a single observer, estimating the weight of forage over a whole site, harvesting at least 10 quadrats as a calibration is probably acceptable.

**Current monitoring packages**

There are many methods of monitoring the vegetation resources in Australia. Some are conducted by the relevant government organisations in each state and have been designed or adapted to meet the needs of their grazing industries.

Vegetation and soil condition monitoring has been described by several authors in the past including Friedel and Shaw (1987), Friedel (1989), Tongway (1989), Catchpole and Wheeler (1992), Christie (1978), Christie (1981), Holm (1984), Forge (1995), Tynan et al. (1992) and Evenson (1992). Tothill and Gillies (1992) used a simplified three-level ranking based on an integrated vegetation and soil assessment for the pasture lands of northern Australia on a broader scale. Every monitoring system has a place, and there is no set recipe for how condition assessment may be conducted. The future application and interpretation will determine which system may be used.

In order to determine the condition and productivity of a pasture, vegetation must be assessed in terms of condition, i.e. its state at a point in time and the trend over a period of time. From this, a number of methods of assessing condition and trend of our vegetation have emerged. (Brief summaries of various packages are detailed in Appendix 1.)
Soil condition monitoring

Soil is the fundamental resource in the rangelands and the maintenance or improvement of the soil productivity is a basic goal for range management (Tongway and Smith 1989). As such, soil monitoring should be an integral part of the rangeland monitoring procedure. This will allow trends in soil condition to be assessed in relation to the pasture component and the management practices. Generic methods of soil condition assessment have been less widely adopted than vegetation monitoring. If only vegetation is monitored, it will not be clear whether changes in plant composition are due to interactions between grazing animals and vegetation alone or whether the soil as a habitat for pasture plants has been degraded (Tongway and Hindley 1995).

Soil degradation is an important factor in the productivity of the rangelands. Soil erosion, often the cause of permanent degradation, can be a contributing factor in the reduced productivity of the soil resource base, plant diversity and ultimately pastoral productivity. Just how much the rate of soil loss contributes to lower productivity is difficult and expensive to determine. Documentation of the long-term reduction in net primary production may be less informative than methods of direct assessment to determine the capacity of the soil to support plant growth (Tongway and Smith 1989). Never the less, identification of those factors that contribute to soil degradation ultimately has a bearing on the productivity of the grazing enterprise. By acknowledging these factors within the monitoring program, remedial action to counter them can be implemented on a broader scale.

Most soil erosion problems in the grazing lands are associated with the removal of the ground cover, often by grazing, mechanical means from grading roads and fence lines, and increased grazing pressure around dams and water points. Careful selection of site for improvements is a key consideration.

Tongway’s manual on soil condition assessment (1995) outlines a comprehensive monitoring program derived from research into the ecology of landscapes. Such a procedure should be included into any program monitoring vegetation, but must not be so time-consuming that its use is prohibitive.

Tongway’s method utilises three principle steps:
1. describing the geographic setting of the site
2. characterising the spatial distribution of fertile patch/inter patch association and identifying the mode of erosion
3. assessing the soil surface condition of the patch types identified.

Management implications

Determining the impact of management practices upon the vegetation resource makes it possible to assess whether degradation is occurring or is imminent. This can be done by assessing the land/pasture capability to support pastoral activities and producing records to gauge trends of the status of the rangeland ecosystem.

There is a variety of approaches that places different emphases upon the relative importance of component species. For pastoral land use, the vegetation measures chosen should reflect the contribution of various plants and key species, while biomass and canopy/ground cover determine the degree of soil protection. A large biomass of unpalatable plants (weeds) may provide good ground cover, but productivity will be low. Classification of species into increaser species and decreaser species assists in interpreting range trends relative to a reference point in time or space. Classification of species as being desirable or undesirable will indicate productivity implications, but the relative frequency and yield of these species will be important.

Range assessment should be undertaken in close collaboration with a resource survey and inventory. This should include: climate, geology, soils, vegetation, water, animals, land tenure and land use.
The major criteria for measurements at NAPCO sites are ground cover, pasture yield and relative abundance of key species. This will assess how well the ground is covered from potential erosion problems, how much feed is there and how many stock can be run in a given area over a given time, how common are the desirable and undesirable species and what is happening to them over time. Relative changes in these species, along with changes in animal numbers, will provide some indication of trends at the ground level.

Annual plant species can contribute substantially to pasture yield under favourable seasons, for example in the seasonally flooded channel country. Annual species are valuable fodder when green and protect the soil to some degree, but they contribute little to the stability of the landscape.

Perennial species are the major contributors to yield and to cover and thus to the stability of the system. Thus it is beneficial that the relative abundance of desirable perennial species should remain constant over time and preferably should be a high proportion of the composition. Perennials fluctuate less wildly in response to seasonal changes, and will seed well from good summer rainfall. Management can be adjusted in late summer to encourage seed set of desirable species and discourage heavy seeding of the more undesirable ones. Paddocks which are continually grazed at moderate to heavy stocking rates tend to develop clumps of unpalatable species because stock avoid these patches. Pasture composition assessment will give an indication of the condition of such spatially variable pastures.

In large paddocks, stock selectively graze vegetation based on its palatability and the distance to water. From an increase or decrease in grazing pressure, the vegetation component can then be assessed in terms of increaser and decreaser species and the relative proportions of each can then be determined. Management can then be adjusted accordingly.

At a practical level, if we expect land managers to go to such lengths in vegetation assessment and recording, their knowledge and awareness need to be improved. Many managers still have difficulty in identifying the pasture plants they are dealing with, and indeed, with seasonal fluctuations, there is an enormous variety of grasses, herbage and woody plants. Identification of indicator species of pasture health is an important first step in the monitoring process. Monitoring sites on NAPCO properties attempt to take account of spatial variability in that they are initially selected from scaled Landsat satellite imagery in close cooperation with each station manager. However, at best there are only two sites located in any one given land type. To date, satellite imagery is not used on an annual basis for vegetation monitoring, but, in the future, successive scenes of a property (perhaps every 5 years) could be used to examine changes over time.

The NAPCO utilises a basic geographic information system to map property features, record physical data, locate monitoring sites, map areas of paddocks and land types, livestock numbers and changes on a paddock and land type basis. This system can be linked to other data bases and station records for interpretation.

Corporate pasture monitoring

The North Australian Pastoral Company Pty Limited is a privately owned grazing operation; it was founded in the Northern Territory in 1877 with the taking up of the Alexandria Station lease on the Barkly Tableland. Today, the Company owns and operates 10 grazing properties across a range of country from the Barkly Tableland, to the channel country, Gulf and central western Queensland. The properties cover an area of approximately 57,000 km², primarily on Mitchell grass downs, but also on the floodplains of the Georgina and Diamantina Rivers. NAPCO also operates a 7,500 head feedlot, “Wainui”, on the Darling Downs as well as being a joint venture partner in a processing plant at Grantham in the Lockyer Valley. The Company runs approximately 130,000 head of cattle, most of which are processed through the “Wainui” feedlot.

NAPCO is now conducting objective soil and vegetation monitoring on most of their properties. Some monitoring sites have been established longer than others, and others have yet to be established.

There are now more than 160 GrassCheck monitoring sites located on 10 pastoral stations in the Northern Territory and Queensland; the longest have been running for just over 7 years and are starting to show some trends in the condition and composition of the vegetation.

The sites have been located in pasture communities considered to be a fair representation of those land types found on each station. Due to the number of sites, measurements at each have been kept relatively simple, but have been designed to measure the most important attributes of the system. Friedel (1987) suggests that rapid and reliable techniques are necessary for monitoring the arid rangelands, and we, as resource managers, must opt for a pragmatic approach to our monitoring.
The monitoring procedure currently employed by NAPCO is kept relatively simple so that managers can understand the process. It is carried out in close cooperation with each station manager—some of whom having been monitoring themselves for some time. Many have set up sites, taking photographs and conducting assessments. Managers are aware of the importance in monitoring the resource base, but time limitations can pose problems in monitoring at the right time.

The present monitoring procedure is that documented by Forge (1995) in the GRASSCHECK manual. This provided the methodology to set up a large number of sites across a broad geographical area. The GRASSCHECK system has been modified since its implementation, and elements of other monitoring programs have now been incorporated into the procedure.

Any one property has 20–30 monitoring sites located, where possible, on all land types. In most cases, at least two sites are selected in each land type to account for variations in soils and vegetation, with some sites including a rain gauge. Sites are marked with two steel posts placed approximately fifteen metres apart in a north-south orientation, and are located using a Global Positioning System in case the posts are knocked over, lost or borrowed. Cattle congregating around the posts at the monitoring sites pose some problems and alternative site markers are being investigated.

Where possible, sites are located 2–5 km from a fixed or permanent watering point, either a bore, ground tank or a waterhole, and generally on the southern side to take account of grazing behaviour into prevailing winds. Some sites are located further away from a water point with a maximum distance of about 7 km. We also monitor some exclosures (fenced and not grazed) as reference sites.

A standard 35mm photo of the site is taken in a southerly direction, with a small blackboard bearing site number and date to facilitate site identification and to allow for annual comparisons. Each site consists of a 300 m long transect on a southerly bearing from the 2nd picket. A ½ m² quadrat is used for all measurements, with 50 quadrats recorded along the transect at approximately 6 m intervals. Each site is rated for a percentage ground cover index, percentage species composition (including indicator species), a pasture condition rating on a 1-5 scale based on these indicators, a pasture quality rating, and an estimation of biomass (kg/ha) based on photo-standards. An approximate estimation of biomass is also done at each site at the end of the transect line, along with a soil surface condition rating. Stock numbers are recorded from the paddock book, while any other relevant comments (rainfall, native animal grazing pressure, etc.) are recorded in a comments section.

The biomass estimation forms the basis of estimating and reviewing stocking rates for the coming year, based on a certain level of utilisation. While concerned with the stability of our grazing lands, animal productivity from them is also of prime importance. The end result is a calculation of a "biological" stocking rate, which may not necessarily involve a change to actual stock numbers on the
property as there is the flexibility of moving within or off the property. A compilation of results over the years produces a number of trends that can be useful for deciding changes to management practices for that paddock or land type.

At present the monitoring is conducted, when possible, in April or May, to gauge the extent of wet season growth and to get some idea of stock numbers that may be carried through the coming dry season. Monitoring later in the year reduces the effectiveness of being a predictive measure for the coming season, and can cloud the results as there may be a completely different suite of plants growing after late summer rain or winter rain. Consequently management objectives may change.

It is all very well to measure these attributes, but what do we do with the information once it has been collected? Monitoring results provide an indication of the current soil and vegetation condition on a given area, but it is vital that this information be interpreted in the context of animal production and sustainable grazing. This biological data should then be linked with physical data collected through the yards on each station. As NAPCO operates a feedlot, weight and age characteristic of cattle must be considered carefully before they are sent there. Animals on each growing property are weighed upon arrival and are weighed periodically in representative drafts to gauge liveweight gains—weighing scales are an important part of the operation. From this information, we can target paddocks that have a better pasture component for animals that are being turned off to the feedlot or for weaners.

The information also allows the identification of paddocks that require more intensive management, for example to recover from grazing pressure or adverse climatic effects such as drought. It is then possible to reorder the priority of paddock use within the property.

Some of the monitoring sites have been established to photographically record changes and trends in the density of woody weeds. A number of plant species, both native (Eremophila spp. and Senna spp.) and introduced—parkinsonia (Parkinsonia aculeata), prickly acacia (Acacia nilotica), rubbervine (Cryptostegia grandiflora) and mesquite (Prosopis spp.)—pose problems. Other sites have been specifically located to record features including poisonous plants such as caustic bush (Sarcostemma australe), bare and scalded areas and oldman saltbush (Atriplex nummularia) regeneration. There are also monitoring sites to gauge the effects of fire on different plant communities over time.

Conclusions

The rangelands have been used by the pastoral industry for wool and beef production for over a century. The focus has been on the management of livestock rather than of the pastures on which they graze. As a consequence, some land has been degraded; the composition of the vegetation has changed with undesirable species taking over, soil has eroded and the productivity of pastures has declined.

The decline in the condition of the vegetation resources is reasonably well documented, but there has been little evidence of its impact on animal production. The relationships between the condition of the land and that of pasture and animal production needs to be better understood, and stocking rates are an important part of this relationship.

Fortunately, resource managers can learn to monitor the condition of their pastures relatively easily. There are a number of techniques that are easy to use and understand, but which method to use depends on why the monitoring is being conducted. By monitoring the condition of pastures and soils, managers can gain a better understanding of the resources and gauge trends in their condition, adjusting management accordingly.

However, monitoring will not make your pastures better, it is only a tool that allows you to look at the pasture more closely. The results can provide benchmarks against which to gauge improvement.

Pasture monitoring means different things to different people. To some, it is a means of feed budgeting and assessing pastures for animal performance, to others it can be an ecological assessment of the health of the vegetation base. One has to ask why we are monitoring and what we want to get out of it. The simple answer is you get out what you put in—do nothing, get nothing.

The hardest part of any monitoring procedure is starting; once this is done, the rest will follow. The best advice is to go out and do it, 'Look into your pastures, not over them'.

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References


Appendix 1

Monitoring packages now in use

Queensland

GRASSCHECK

The GRASSCHECK monitoring procedure as described by Forge (1995) and Forge and Ritchie (1994) is a simple procedure that encourages graziers to monitor the condition of their grazing land. It consists of a 7-step process starting at a basic first step of taking a photograph at a fixed point. Users can then work their way through the remaining steps, progressively gathering more information. This system is a more applied technique and incorporates basic plant identification, measurements and recordings with animal production and performance. Sites are chosen much the same way as described by Holm (1984). They can be up to 5 km from a fixed water point for cattle and 1.5 km for sheep and are located in a north-south orientation. Sites are photographed with a standard 35mm film.

A grazing record of the paddock is maintained, with stock in and out of the paddock being measured, as well as an estimate of native and feral animals on a low, medium and high density. Standing feed is estimated on a kg/ha basis using photographic standards. Fluctuations over a period of time can then be recorded. Species can be collected and identified and pressed for future identification records. Two methods of assessment can be used, the step-point procedure or the use of a quadrat. In each, an estimate of ground cover and species composition and frequency is conducted. The step-point method uses a ground cover percentage based on grass/herbage, woody plants, litter and bare ground while the quadrat method bases ground cover on a percentage and scale basis of the quadrat. Frequency tallies are compiled to give each species a relative frequency percentage for that site.

Tree and woody plants are recorded on the site, as is the soil surface condition. Stocking rates can be estimated from either rainfall use efficiency figures, which calculate a long term safe stocking rate for a land type, or from photo-standards of estimated pasture yield at time of assessment. Sites are recorded on an annual basis and information derived from these sites can then be used for forward feed budgeting and stocking rate adjustments for the coming dry season or some other grazing period. This procedure can be as simple and as complex as the user wishes and allows flexibility in how the procedure can be used.
Q-GRAZE

Q-GRAZE (Queensland Grazing Land Monitoring project) is designed for monitoring the changes in condition of the state’s grazing lands; it is part of a state-wide brief to assess the condition of the grazing resources and to ensure sustainable grazing practices within the pastoral industry are adopted. Sites are established to record changes in the condition of vegetation and soil surface over years. These changes are then interpreted in terms of the factors causing them. Summaries are provided on a 5-year basis. Information collected is provided to a number of interested parties including pastoralists, administrators and the general public.

Sites are photographed and recordings are made, ideally at the end of the growing season. A number of important attributes are recorded including quadrat data (ground cover, pasture plants and woody plants) and site data (yield, composition, soil surface condition, tree counts, basal areas and disturbance). Q-GRAZE sites are monitored initially one year from establishment and then re-recorded at intervals of three to five years.

GRAZON

The GRAZON program is an adaptive management tool for ecological and economic sustainability in the Mitchell grasslands (Cobon 1994). It is designed to calculate safe stocking rates of paddocks based on objective measurements of their size and spatial characteristics—soils, vegetation and total grazing pressure.

GRAZON provides a framework for pastoralists to make objective measurements as part of the process of assessing the capability of the land to sustain sheep and cattle production. It contains a manual detailing the strategy, the monitoring techniques, data recording sheets and photo-standards. The decision support program includes computer software to calculate safe stocking rates.

GRAZON develops a grazing management strategy which determines, at the end of each growing season, a livestock carrying capacity based on a number of factors, including pasture biomass. The grazing model adjusts grazing pressure by taking into account the condition of pasture, species composition, stock selection preference, spatial distribution of grazing pressure and inter-seasonal forecasting of pasture growth. Carrying capacities can then be adjusted in paddocks to take into account pasture and seasonal conditions as well as the pressure from non-domestic grazing animals (Cobon 1995).

BOTANAL

BOTANAL is a comprehensive versatile sampling and computing procedure for measuring pasture yield and composition based on calibrated estimates as described by Tothill et al. (1992). It is based on the dry weight rank method of measuring relative composition described by Mannetje and Haydock (1963) and the relative weight estimate method for measuring pasture dry weight of Haydock and Shaw (1975). Other measurements such as species frequency in composition, species density and ground cover can be included. While the package has been used by researchers mostly in more intensive assessments of grazing experiments, it can also be applied to large- or small-scale situations. Its complexity of use stems largely from the computing package which was necessary for meeting the requirements of researchers.

Plate 2.3.2. BOTANAL—the most comprehensive package for measuring 'Dry Weight Rank' of tropical pastures.
Western Australia

Western Australian Rangeland Monitoring System (WARMS)

This system being used in Western Australia aims to provide a means for objective assessment of changes in vegetation and soil surface condition of grazed shrubland pastures (Holm 1984). It utilises a series of rangeland monitoring sites within paddocks on pastoral leases as well as a series of pasture land benchmarks on ungrazed reference areas, selected on a regional basis. Sites are set up according to first order or second order criteria. First order sites are established where there is a minimum number of desirable perennial plants (400 plants/ha), with plant populations measured along belt transects and soil erosion described by an index; second order sites are selected where a thorough site assessment is not warranted, as they do not support a specified minimum number of useful plants.

Sites should be selected in one land type, no further than 2.5 km from water (Holm 1984). Sites should have reasonable vehicle access, be in country in fair condition and not be located in dry corners of paddocks, along fences or in favoured areas. Sites should be photographed and recorded every 4–5 years along belt transects. Four fixed parallel transects, each a maximum of 100 m x 4 m, are assessed by two recorders. Soils are described and the surface condition rated; plants are tagged in the first year and width and height of each perennial plant is recorded along the transect. Benchmark sites are recorded every two years.

Northern Territory

Monitoring rangelands in the NT

Rangeland in the Northern Territory is monitored in conjunction with the Pastoral Land Board and the pastoral industry as a 2-tier procedure. Tier 1 involves a photopoint-based system at the property level and aims to assist lessees with management decisions by documenting change over time. These sites are visited every twelve months.

Tier 2 involves monitoring by government agencies at a regional level, and is a combination of photo-point monitoring and more detailed objective scientific information on range condition (N.T. Dept Lands, Housing and Local Govt, 1995).

This system provides a series of guidelines that assess pasture species and the composition of perennial and annual grasses, forbs and other herbage. Non-edible woody weeds and shrubs are also identified. Samples can be cut and dried and weighed to establish benchmarks of various species. Woody shrubs are recorded and estimated on a density basis, using ten 2 m x 50 m belt transects to express numbers per hectare.

Sites (250 m x 250 m) must be representative of a pasture type or land system, and should be 3–4 km from permanent water or larger ephemeral waters. Other factors to consider when selecting a site include livestock behaviour, bore salinity, supplementation sites, yards, tracks, erosion, general condition and state of site etc.

Centralian Range Assessment Program

The Centralian Range Assessment Program (Bastin 1989) assesses the land capability and range trend of important pasture types in randomly selected areas. The permanent sites are marked with steel pickets; they are photographed, and the pasture components measured. Measurements include herbage species composition at the site and at benchmark sites (exclosures). Pasture yield, species composition and species frequency is assessed using a modified comparative yield and dry weight ranking procedure. Photo-standards for comparative yield estimation are used for future estimates. An estimate of the feed condition, forage quality, abundance, vigour and forage species utilisation, including an assessment of desirable, undesirable and ephemerals plant species and seasonal rainfall is made.

The soil surface status, erosion types and severity are described along with descriptive tree and shrub information. The fire history of the site, site productivity limitations, grazing use and land capability are also detailed in the recording and assessment. Conditions and trends on the site are compared against the exclosure sites and an indication of rate of change is determined.

There are a number of features of this methodology that have practical application to grazing management and the determination of grazing capacities. Effects of cattle grazing intensity on the pasture condition can be determined, climatic extremes and fire can be superimposed on grazing pressures and the relative proportions of increaser and decreaser species, and the effects of grazing on the vigour or density of pasture can be determined. The Centralian Range Assessment Program is a comprehensive monitoring program that can have an application on a broader scale.
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Sullivan and Egan (1996) have also detailed comprehensive data collection methods for land resource monitoring including selection of monitoring sites, site identification and layout, timing and frequency of assessments. The procedure includes measurements such as species composition, pasture yield, cover, frequency, tree and shrub cover and density and utilisation. This method is aimed primarily at officers involved in land resource monitoring and is a compilation of procedures which can be used to monitor rangeland attributes. It has been developed to meet the requirements of the Pastoral Land Act (1992) and assist the Department of Land, Planning and Environment's role in providing advice on resource management and administering relevant resource management legislation.

RANGEPAK/HERDECON

RANGEPAK is a computer-based advisory system to aid pastoral management (Stafford-Smith and Foran 1990). It brings together the business and financial aspects of property management with those of the biology of the herd or flock. RANGEPAK is a more sophisticated package but is not described as a true monitoring package, in the sense that it provides a series of guidelines for assessment 'on-ground'. It is more a case of monitoring the overall production system, including stock, finances and productivity.

The application of this program is most valuable in that it provides for a process of planning ahead, for comparing alternatives and for making informed decisions for the future. The program allows for climatic and market variability and testing new approaches to see the effects on herd structures and cash flows. RANGEPAK/HERDECON has the ability to extend ground-based monitoring into tangible economic scenarios.

South Australia

Monitoring on the pastoral lands in South Australia falls within the boundaries of the Pastoral Land Management and Conservation Act (1989) and is administered by staff within the Department of Environment and Natural Resources' Pastoral Management Branch. This act requires that leases be assessed for range condition, their problems identified and carrying capacities determined (Jessop 1992). The monitoring procedure employed uses random survey points on each lease. A photograph is taken of the site, the pasture component is identified and an appropriate condition state is determined using photo-standards. A land condition index is calculated for each lease and is then compared to similar leases of pasture composition. The board is required to specify a maximum stocking level for the lease, and the lessee is not permitted to exceed this figure. Other factors such as number and location of waters, number of stock per water point, paddock size, grazing management, season and other land management problems are also considered (Tynan et al. 1992).

New South Wales

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The NSW monitoring program commenced with a pilot study in 1982; after analysis of results and methodologies, the current system was established in 1989. Range types across Western NSW were stratified and a minimum number of range study sites established on seven out of the eleven identified range types. Over 340 sites of 500 m x 500 m have been established and are assessed annually. An internal 300 m x 300 m area is assessed by both transect and quadrat-based methods. Standard photographs are taken at each site. Soil surface condition, ground species composition and biomass, bush and shrub seedling occurrence and ground species occurrence are recorded in each quadrat. Woody canopy cover and chenopod bush density are measured by step-point transect respectively. Site location is permanently recorded by pegs with GPS coordinates being mapped onto a GIS. All data is recorded electronically in the field and down-loaded on to a central data base. Site reports for landholders are automatically generated.