Department of Environment
and Resource Management

Land Manager's Monitoring Guide

Ground cover indicator

Tomorrow's Queensland:
strong, green, smart, healthy and fair

Toward Q | Queensland Government

Prepared by:

Environment and Resource Sciences

Department of Environment and Resource Management

August 2010

Contents

What is it?

Ground cover is provided by living or dead plants and any of their parts that fall to the surface of the ground.

Cover may also be provided by pebbles and rocks or a crust of cryptogamic materials (plant life without 'true' flowers and seeds, such as mosses, lichens and fungi). Groundcover may be considered as being anything below your eye level that intercepts a vertically falling raindrop.

In most landscapes under natural conditions, there is usually some form of cover on the soil surface. Exceptions include environments that are inhospitable to plant growth including degraded or eroded landscapes, some deserts, and salt pans. In forests, much of the ground cover is provided by fresh or slightly decomposed leaves, bark, fallen logs/limbs, twigs, flowers and fruits (collectively referred to as forest litter). In woodlands and grasslands most of the cover is provided by a variety of herbaceous plants and low growing shrubs. In arid and sub arid Australia, cryptogamic crusts can provide a significant amount of ground cover. These crusts are made up of various cyanobacteria, lichens, mosses and fungi.

Cover is also provided by crops and the stubble that remains after harvest. Weeds have few positive benefits, but the ability of many weed species to rapidly colonise an area can provide effective ground cover. In the urban environment, cover may be provided by landscaped surfaces, gardens and infrastructure such as concrete, bitumen and buildings; however such impermeable surfaces generate high rates of runoff which may lead to off-site erosion problems.

Tree canopies usually provide minimal protection against raindrop impact and tree trunks have no effect on impeding surface flows. For control of erosion, surface cover is essential and bare areas beneath trees are vulnerable.

The amount of ground cover is constantly varying and is dependent on a range of factors including:

- **plant type**—Plants have different growing habits (spreading or erect), life spans (annual or perennial), and decomposition rates. (The stubble of cereal crops can provide protection for up to 12 months while the leaves of some crops such as sunflower, legumes and cotton rapidly break down.)
- **growth rates**—Plant growth is affected by many factors including soil moisture, fertility levels and seasonal conditions.
- **land management**—Grazing, crop and fire management practices have a major impact on ground cover levels.

Ground cover has a number of important functions relating to productivity and environmental health:

- It prevents water erosion by absorbing the impact of falling raindrops that may otherwise cause the soil surface to seal and contribute to excessive runoff.
- It reduces the velocity of runoff and encourages it to spread out rather than to concentrate and develop into an erosive force. Organic matter (including animal dung) and soil can be deposited when overland flow is obstructed by surface cover. Such accumulations are referred to as 'sinks' or 'fertile patches' (Tongway 1994) where the additional water and nutrients provide an improved environment for plants to germinate and grow.
- It prevents erosion from wind by reducing the wind velocity adjacent to the soil surface and provides an effective barrier between the soil and the air above it.
- It moderates the temperature on the soil surface and helps to reduce evaporation rates from the soil surface.
- It is a natural habitat and food source for a wide variety of living organisms and is used to assess and monitor the health of native vegetation.
- It allows for the recycling of nutrients as plant products are allowed to decompose and nutrients are returned to the soil.

Other factors and related indicators

Consideration could be given towards monitoring the following indicators that have an association with ground cover:

- Hillslope erosion
- Gully erosion
- Wind erosion
- Water infiltration
- Pasture composition
- Native species richness

- Soil condition
- Saline land
- Impact of fire
- A range of indicators relating to water quality.

Why monitor this indicator?

The section 'What is it?' indicates the essential role that ground cover plays in ensuring the healthy functioning of a landscape. Land management practices that contribute to low levels of ground cover leave the land vulnerable to land degradation. Monitoring ground cover can:

- help you assess the degree of risk of land degradation occurring
- determine landscapes that are already in a degraded condition.

Graziers make a mental note of the condition of their pastures during their day-to-day activities on the property. However, it becomes difficult to recall how the pastures may have looked in previous seasons unless some observations have been recorded. Our memories can be short, confused or biased; a documented record allows comparison with previous seasons and allows the data to be shared. Grazing lands that have a consistently low level of cover provide a strong indication of excessive stocking rates and degraded land. Figure 1 shows how photographs have been used to compare pasture condition at the same point over a span of three years.

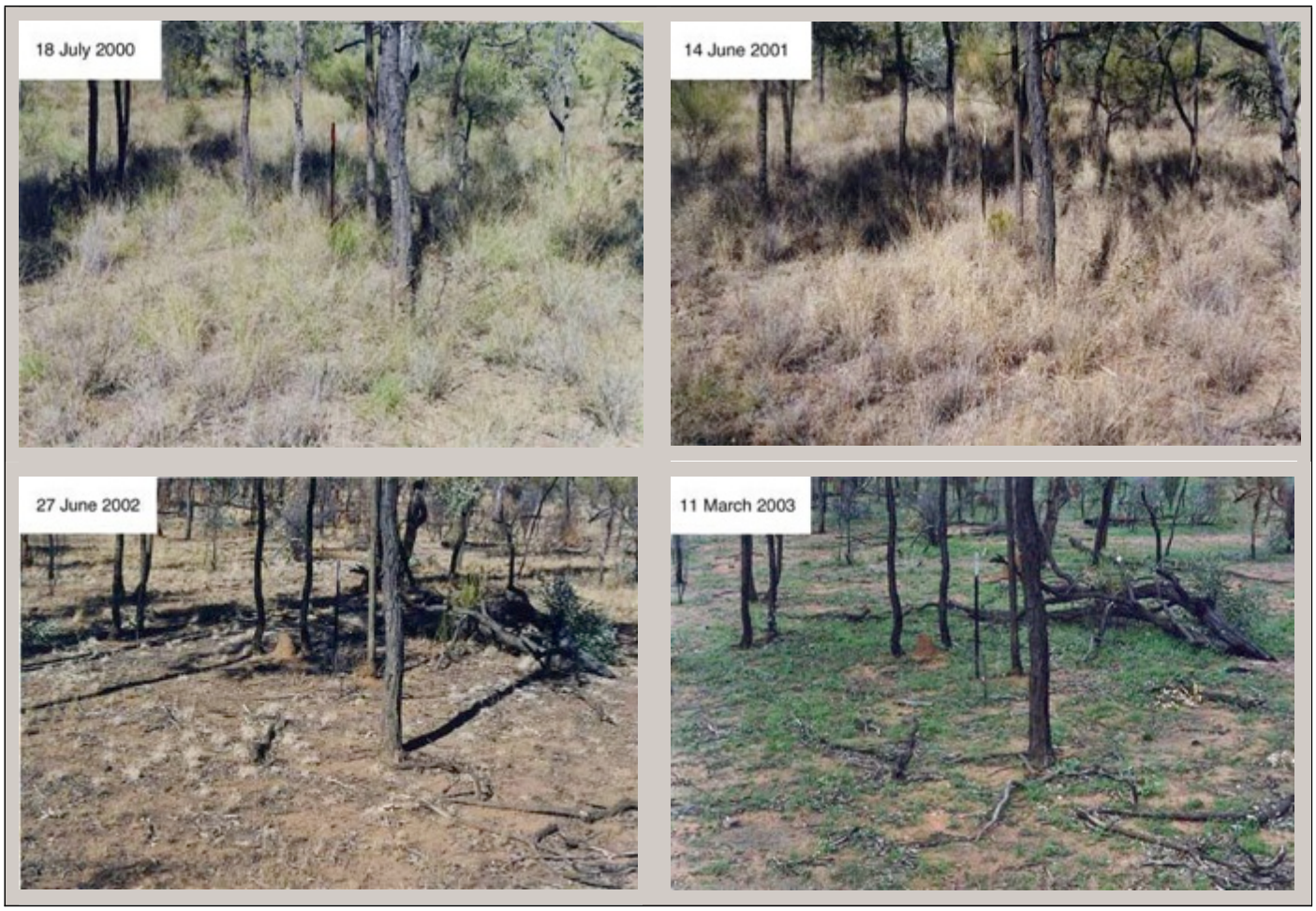

Figure 1: Photographs comparing ground cover at the same point over a three year span

Cover levels in cropping lands may vary dramatically depending on land management practices, the stage of growth of the crop and the crop type. An alternative to regularly monitoring ground cover in paddocks used for cropping is to monitor the adoption of land management practices that affect cover levels, for example, fallow management techniques such as zero tillage and green cane trash blanketing may provide 100% cover throughout the year.

At the catchment scale, an overall indication of ground cover can be used as an assessment of catchment health and the vulnerability of the land to soil erosion and its associated impact on water quality. Techniques such as cross-landscape transects and assessment of satellite imagery can be used. By monitoring on a regular basis, relevant stakeholders can assess change in ground cover levels and associated land management practices over time.

Ground cover measurement is an important component of assessing the health of a landscape from a biodiversity viewpoint. When making observations for biodiversity purposes, we are interested in the different components that make up ground cover, rather than the total amount of cover.

Planning to monitor this indicator

What are your monitoring objectives?

Consider what you are trying to achieve by monitoring ground cover. You may just be interested in the total amount of ground cover, or for an assessment of biodiversity you will need to assess the amount of cover provided by different components such as native plants, weeds, litter and rocks.

If you are confident that your land management practices are consistently providing adequate levels of ground cover, then there may be little point in measuring it. Land managers should be aware of ground cover levels under different land use and management practices because it affects the susceptibility of their property to land degradation. Of special interest is any land with cover levels of less than 40%.

As ground cover may be subject to considerable variation from month to month, there is generally not a great need to monitor it with a high level of precision. A visual assessment of ground cover, as provided in Level 1 of 'How do you measure it?' will provide you with a method of making a rapid assessment of ground cover. Measurements at established sites can be taken to provide a higher level of accuracy, as described in Levels 2a (for overall ground cover) and 2b (for biodiversity assessment) of 'How do you measure it?'.

You also need to consider other indicators that you may wish to measure, for example, if you wanted to monitor plant species as well as cover, you would need to take more measurements if you had an interest in finding rare plants.

How will your data be used?

Primarily your data will be for your own use. However other land managers, catchment groups or your regional body may be interested in your ground cover monitoring. Some regional bodies have set targets of ground cover that they hope land managers in their region will be able to achieve. If you intend to share your data with others, you should check to see if your proposed data collection procedures will be compatible with theirs.

What will you monitor?

Existing standards

Some Queensland Government programs, including the Reef Protection Package and Delbessie Agreement (for renewal of rural land leases) have monitoring requirements tailored for each program, but based on existing monitoring methods. These requirements may be fulfilled in part by the methods in this and other indicator guides, however if your property occurs in selected reef catchments or includes leased land you should refer to the specific guides provided for these individual programs. These include guides for producers that are preparing Environmental Risk Management Plans (ERMPs) under the Reef Protection Package <http://www.reefwisefarming.qld.gov.au/> and for land condition assessment under Delbessie land management agreements <http://www.derm.qld.gov.au/land/state/rural_leasehold/land_cond_assessments.html>.

There are no formal standards for monitoring ground cover in Queensland. The use of a quadrat (described in Levels 2a and 2b of 'How do you measure it?') is recommended in order to estimate percentage ground cover. Comparisons can be made with graphical presentations (Figure 2) or photos of a range of different cover levels (Figure 3).

Figure 2: Examples of ground cover patterns as they appear in a quadrat for 5%, 15%, 30%, 50% and 90% cover (Department of Natural Resources 1997)

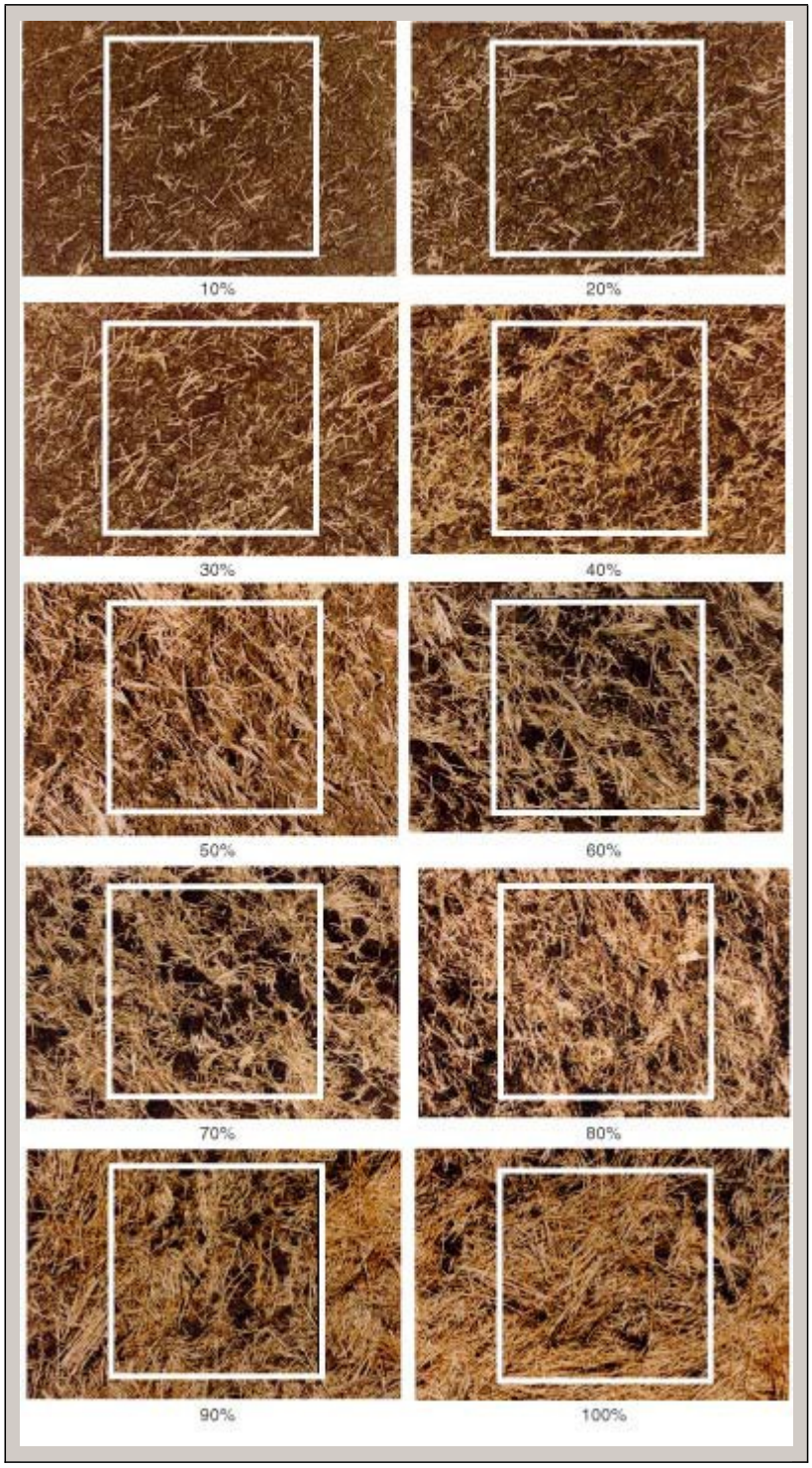

Figure 3: Photographs of wheat stubble cover levels in 10% increments (Molloy 1988)

The spreadsheets provided for Level 2a and 2b allow you to add quadrat measurements in increments of 10%. The spreadsheet will then calculate an average cover level for the site.

An alternative way of grouping cover levels into categories is provided in Grass Check (Department of Natural Resources 1997). These categories are less than 5%, 5–15%, 15–30%, 30–50%, 50–90% and >90%. This categorisation places emphasis on the measurements at the lower end of the scale because surface cover levels are considered to become critical once they drop below 30%.

When monitoring for biodiversity assessment, your data can be compared with benchmark data prepared for the vegetation

zone or regional ecosystem you are monitoring. It is intended that this information will become available on the Queensland Department of Environment and Resource management website.

The CD, 'Pasture photo standards' (Department of Primary Industries 2003) provides colour photos of oblique views of different pasture types (Brigalow belt, Channel country, Central Queensland coast, Cape York Peninsula, Desert uplands, Einasleigh uplands and Wet Tropics, Gulf Plains, Mitchell Grass Downs, Mulga Lands, North West Highlands, Wide Bay and Southeast Queensland, and Southern Brigalow and New England Tablelands). For each pasture type there are photos of six pasture yields from very low to very high. The photos can be used for estimating the amount of fodder available (in kg/ha) to assist in determining future grazing strategies. Because they are oblique views, they are not suitable for directly estimating ground cover as they can tend to result in overestimating the real value. The CD is available from the Queensland Government Bookshop <https://www.bookshop.qld.gov.au/> - Search for ' Pasture photo standards'.

Existing monitoring in your area

Before you start monitoring any indicator, it is recommended that you explore who else is monitoring in your area, what they are monitoring and how they are monitoring it. Doing this will not only make sharing your data easier if you choose to do so but will also help you become more familiar with:

- Any area-specific issues that may influence your monitoring
- What strategies and/or methods have proven successful within your area.

Where will you monitor?

You need to determine whether you will monitor ground cover levels on the whole of your property or selected areas that may be of concern, for example, areas that may have cover levels that are less than the critical value of 30–40% (either permanently or occasionally).

If you decide to establish monitoring sites, a decision is needed on whether it is better to take many cover measurements at one site in a paddock or to make a similar number of measurements spread over a number of sites. There are no hard and fast rules as to how many sites you should monitor in a paddock and how many observations you should make. The sites should be accessible and away from fences, tracks, waterways and watering points to ensure that they are representative of a large area of your paddock. Aerial photos or satellite images may be useful in assisting with site selection.

Where different land types occur in the one paddock or where there are areas of special interest (e.g. an area being rehabilitated), it is preferable to have at least one site in each system or zone. The records for each system should be kept separately, since averaging them may lead to a misleading result. For example, if one half of a paddock has 20% cover and the other half 80% cover, the average cover is 50%. This approach does not convey the message that half of this paddock is at high risk from land degradation and may indicate a case for creating an additional paddock so that appropriate management practices can be applied.

To monitor for BioCondition Assessment <http://www.derm.qld.gov.au/wildlife-ecosystems/biodiversity/biocondition.html>, ideally all vegetation types and all areas subject to different levels of management on the property should be monitored for ground cover. The combination of a particular vegetation type and management action is called a zone. Considerable thought needs to go into the placement of your monitoring areas within these zones to minimise the number of sites but to still ensure you represent the range of vegetation and management actions on the property.

When and how often will you monitor?

While adequate cover levels are desirable throughout the year, the summer months represent the period of highest erosion risk in Queensland. Figure 4 shows the average monthly erosivity value of the rainfall for Emerald and Pittsworth. Erosivity combines the amount and intensity of rainfall and is highly related to erosion potential.

This period of high erosion risk is a desirable time in which to monitor ground cover. However, in grazing lands there are advantages in monitoring pastures at the end of the growing season, around April. This allows graziers to make decisions on future stocking rates. An added bonus is that temperatures at this time of the year are more comfortable for field monitoring!

Additional monitoring can be undertaken at strategic times such as during a drought, at the end of the dry season or a month after major rainfall.

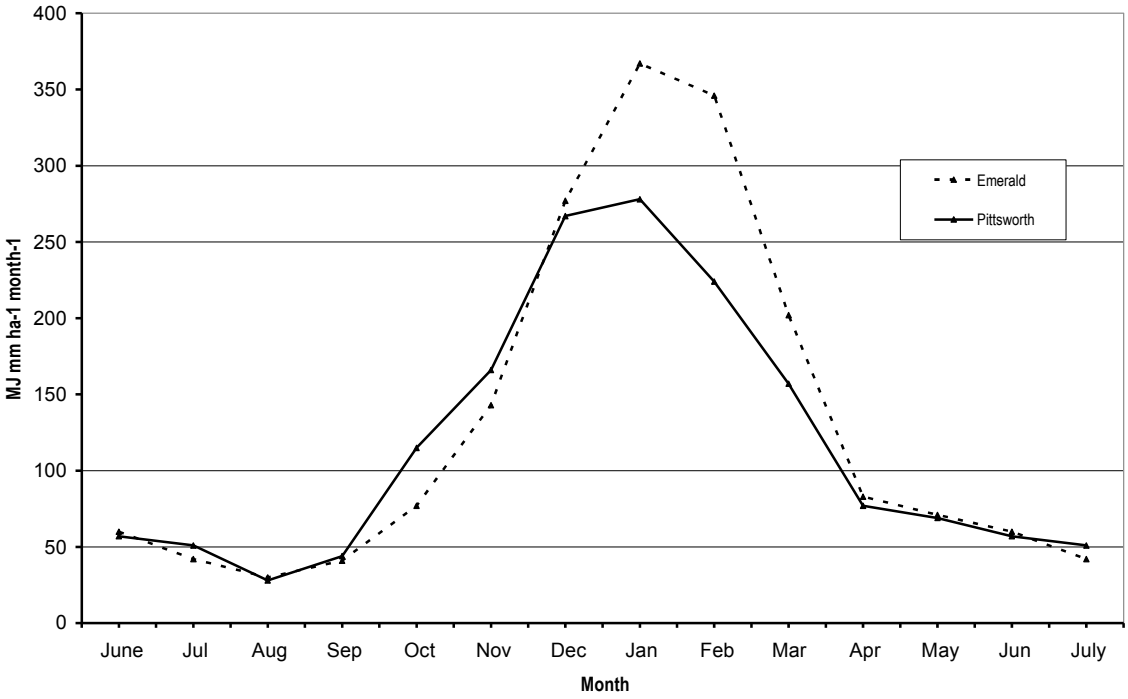

Figure 4: Average monthly rainfall erosivity values for Emerald and Pittsworth

How do you measure it?

For this indicator, two levels for estimating ground cover are described:

- Level 1 involves an overall visual assessment while driving or walking around a paddock. It is appropriate for all forms of land use.
- Level 2 provides a more accurate assessment by estimating ground cover levels using quadrat readings at established monitoring sites:
    - Level 2a describes a system that is most appropriate for grazing lands although it could be used in a cropping situation
    - Level 2b is recommended when monitoring for biodiversity assessment.

A number of methods of measuring ground cover have been published and there are no set rules as to which is the best method to use. However, some Queensland Government programs including the Reef Protection Package and Delbessie Agreement (for renewal of rural land leases) have monitoring requirements which may be fulfilled in part by the methods in this and other indicator guides. If your property occurs in selected reef catchments or includes leased land you should refer to the specific guides provided for these individual programs including those for Environmental Risk Management Plans (ERMPs) <http://www.reefwisefarming.qld.gov.au/> and for land condition assessment under Delbessie land management agreements <http://www.derm.qld.gov.au/land/state/rural_leasehold/land_cond_assessments.html>.

Since ground cover levels are constantly changing, there may not be a need for you to measure with a high level of precision and the visual assessment described for Level 1 may suffice for most situations. In Levels 2a and 2b, the use of quadrats is described for estimating cover levels where a higher level of precision is required.

Besides using quadrats, it is also possible to measure ground cover using a point observation method rather than a quadrat. In this case, a straight piece of wire or a point on the toe of your boot can be used to record the presence or absence of cover. To avoid confusion, this method has not been described in this indicator. A description of such a method can be found in Francis and Payne (2003).

A Queensland Department of Environment and Resource Management state wide ground cover monitoring program reports annually on percentage of ground cover in Queensland based on Landsat imagery starting in 1988. This low cost imagery enables a more dynamic monitoring of ground cover by remote sensing and opens up new opportunities for monitoring and time series analysis of up to 20 images per year. Recent research by the Queensland Department of Environment and Resource Management (as at 2010) indicates that ground cover may soon be able to be monitored remotely and at low cost with the ability to distinguish between bare ground, green vegetation and dry (or non-green) vegetation cover.

The use of photopoints is recommended to support any system of assessing ground cover.

Use of photopoints – photographic records

It is preferable that a photographic record is kept for all ground cover monitoring sites. A sequence of photos taken annually from exactly the same location in a paddock can record changes in ground cover, woody plant populations and feed availability (Figure 1). They show the long-term effects of management as well as short-term changes caused by seasonal conditions and the effects of grazing management.

Photos should be taken on a clear day between 9 am and 3 pm. You will always get a better photo by having the sun behind your back. To do this you need to be facing south (in the Southern Hemisphere!). Photos can be taken from two angles: the 'trayback' and the 'landscape'.

The 'trayback' photo

This photo angle will best illustrate ground condition and the amount of feed available in a pasture. A step ladder could be used as an alternative to a vehicle. The vehicle trayback is set up at the post from which the photo is being taken (Figure 5). Facing south, focus the middle of the viewfinder on the base of the sighter post.

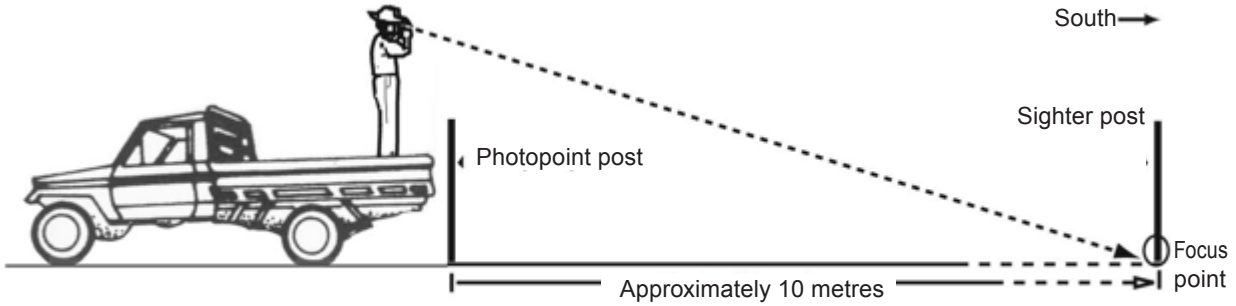

Figure 5: Taking the 'trayback' photo (Department of Natural Resources 1997)

The landscape photo

This photo angle will best illustrate the general condition of the site showing major changes in shrub and tree populations. Stand next to the photopoint post as in Figure 6. Position the top of the sighter post in the middle of the viewfinder and focus on infinity.

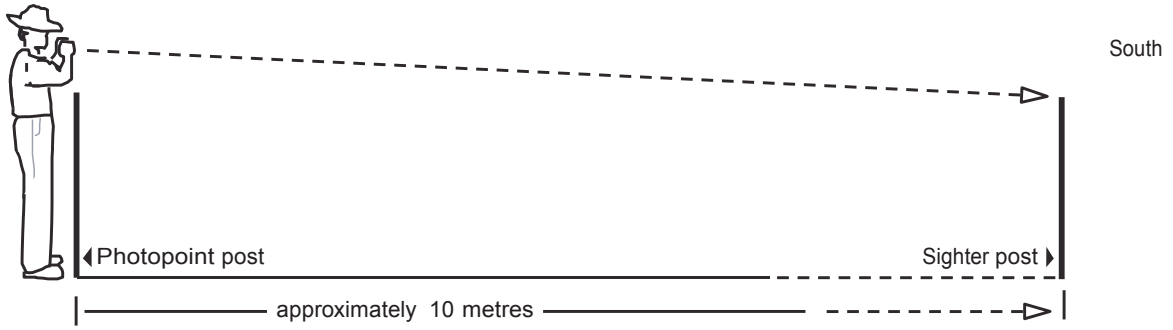

Figure 6: Taking the landscape photo (Department of Natural Resources 1997)

It is a good idea to have a sign on the post in the photograph to indicate the site details. The date should be noted (cameras often have the facility to do this automatically) as well as the time, photo number and site number. If the photos are printed, appropriate details should be written on the back and they should be filed appropriately. If you are using a digital camera, most suppliers provide software for storing and showing a collection of photographs and adding notes for each picture. As with all computer records, you should make regular backups of your electronic records, such as by burning a CD.

How do you measure it? – Level 1 monitoring

Key aspects of level 1 monitoring

Level 1 monitoring involves a visual assessment of percentage ground cover by making a number of observations as you drive or walk around a paddock. The method does not require the use of quadrats although they could be used initially to assist the observer in gaining skills in estimating cover by making comparisons with the diagrams in Figures 2 and 3.

It is recommended that photographs be taken to provide a permanent record as described in 'Use of photopoints – photographic records'.

In grazing lands, you need to decide if you are going to establish some permanent monitoring sites within each paddock or whether you are going to make an estimate by just walking or driving around the paddock. Permanent monitoring sites are useful when taking photographs so that you can compare identical locations over a period of years.

Paddocks used for cropping will generally have much more uniform ground cover levels than grazing paddocks. It is generally not practical to establish permanent monitoring sites in cropping areas because of their interference with tillage, spraying and harvesting activities. It is usually sufficient to make observations of ground cover in cultivated paddocks my making an overall observation. There is little point in going to a lot of effort to establish a precise level of ground cover for a cultivated paddock since the cover levels can change rapidly as a crop develops.

Skills needed

- Knowledge of the paddock or resource area to allow you to determine suitable monitoring sites
- Ability to estimate ground cover. You can 'calibrate' your eye by using some quadrats and making comparisons with the cover levels provided in Figures 2 and 3

Equipment

- A camera
- If monitoring sites are to be established, two steel pegs are required for each site.

Time taken

- 15 minutes to establish each monitoring site (if required)
- 5 minutes per site, plus travel time in moving from site to site

Setting up

If setting up permanent monitoring sites, consideration needs to be given to the information provided in the selection of monitoring sites in 'Developing your monitoring plan'. It may be appropriate to divide a paddock into two or more zones, keeping separate records for each zone. This would be advisable where there were contrasting cover levels in a paddock resulting from different land types or different grazing pressure associated with the location of a watering point.

Install two steel pegs at the selected sites. The posts should be in a north-south direction at a distance of around 10 metres apart and provided with an identification number. For more information see 'Use of photopoints – photographic records'.

Monitoring procedure

1. Make a visual assessment of the cover at the site. Record the percentage cover using 'Recording sheet' (refer also to 'How to record your results').

2. Where monitoring sites are being used, take a photograph from the photopoint post.

Data quality considerations

As this method is only a visual assessment it is somewhat subjective and there is likely to be some variation in the assessments made by different people. As ground cover levels are constantly changing depending on seasonal conditions and land management practices, a high level of precision is generally not required and this method of assessment should suffice for many situations.

How do you measure it? – Level 2a monitoring

Key aspects of level 2a monitoring

Level 2a monitoring involves setting up a 'monitoring triangle' (see 'Setting up', Figure 8) and taking measurements using a quadrat as you walk around each side of the triangle. It is primarily intended for use in monitoring ground cover in grazing lands.

An advantage of using a monitoring triangle compared to a straight line transect is that you end up at your starting point, rather than having to 'backtrack' to the starting point. A triangle may also provide a better sample of the landscape because of the three different directions of travel.

Skills needed

- Knowledge of the paddock or resource area to allow you to determine suitable monitoring sites
- Ability to estimate ground cover percentage within a quadrat
- Basic maths and ability to use a computer spreadsheet for calculating average percentage cover at a site

Equipment

- Four steel posts for each site. Three are required for the monitoring triangle and another for the photopoint post
- A quadrat for measuring cover (can be made for minimal cost in the property workshop)
- A camera
- GPS unit (optional)

Figure 7 shows two different types of quadrats. Grass Check (Department of Natural Resources 1997) makes the following recommendations for their use:

- 50 cm by 50 cm quadrat for areas with more than 500 mm rainfall, or areas with good Mitchell or buffel grass cover
- 100 cm by 50 cm quadrat for other pasture areas.

To facilitate the estimation of percentage cover, the sides of the quadrat can be painted in alternate colours to divide it into 10 cm lengths. An open end allows the quadrat to be used where there are obstructions such as trees or shrubs.

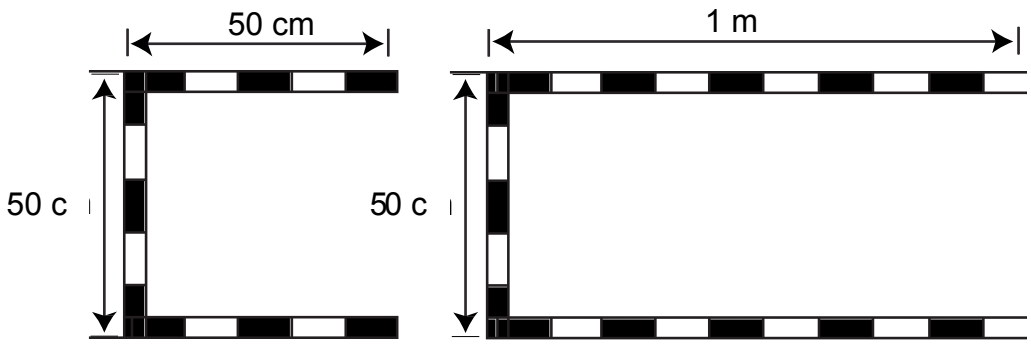

Figure 7: Two types of quadrats used for measuring ground cover

Time taken

- 45 minutes to locate and establish a monitoring site
- 30 minutes to take the recordings and the photograph per site

Setting up

You need to decide how many monitoring sites you will establish in a paddock and where you will locate them. The section 'Where will you monitor?' has advice on selecting suitable monitoring sites.

The monitoring triangle as indicated in Figure 8 is marked out as follows:

1. At the northern end of the triangle, drive in two posts or place markers, 10 m apart in a north-south direction. The northernmost marker is the photopoint point and the other is referred to as point 1.
2. From point 1, measure or step out a triangle with each side 100 m long and place markers for points 2 and 3. The easiest way to do this is to go south 87 m, then 50 m left and right from that point.
3. If the site is covered with trees and shrubs, mark the sides of the triangle with a marker every 50 m or put coloured markers on some trees.
4. The location of each site should be numbered and marked on a property plan. GPS recordings may also be taken.

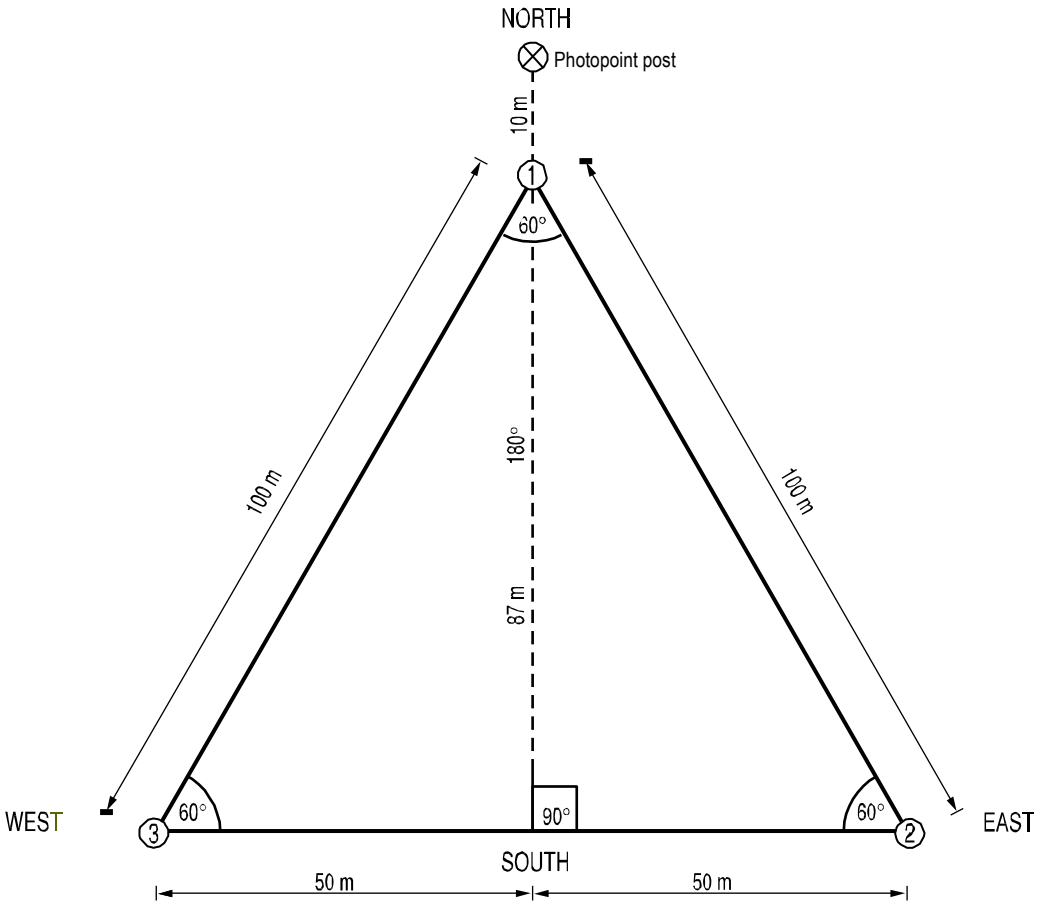

Figure 8: Approximate dimensions for a monitoring triangle

Note that a high level of precision is not required when marking out the triangle. It would be acceptable to use 100 paces instead of 100 metres. It would also be appropriate to reduce or enlarge the size of the triangle (e.g. a triangle with 50 metre sides would be acceptable in small paddocks).

If using steel posts they should be made safe and visible to motor bike and horse riders; for example, attach a piece of PVC pipe over the top or paint the posts white and place a protective cap over them. On open areas such as Mitchell

grass downs, it may be necessary to place some old tyres around the posts to alleviate the effects of stock gathering to rub on the posts and increasing stock pressure in the area.

Monitoring procedure

1. In order to take 50 recordings around the triangle, you would need to make 17 observations on two sides and 16 on the third side. This would mean taking observations at regular spacings of every 6 or 7 paces depending on your length of stride.
2. At each observation point, place the quadrat in front of the leading foot and estimate the ground cover percentage by comparing with Figure 2 or Figure 3. The measurement includes cover occupied by grass, herbage, leaves, litter and manure. Cover provided by low shrubs of less than 1 metre is included but not higher shrub or tree canopy. Tip: Consider cover as being anything below your eye level that intercepts a raindrop that is falling vertically, or mentally 'move' all of the cover to one corner of the quadrat and estimate the cover that way.
3. Record your estimated percentage using the 'Level 2a Recording sheet' (refer also to 'How to record your results').
4. Continue walking around the transect until you have a total of 50 estimates.
5. Take your landscape and trayback photographs at the photosite point. Record any relevant notes that relate to the photo.

Data quality considerations

This technique is based on the method described in Grass Check (Department of Natural Resources 1997). However, the recommended number of observations along the three sides of the triangle has been reduced from 100 to 50. There is a trade-off between the number of observations you make at a single monitoring site and the number of sites you have in a paddock. There is little point in making a large number of observations at one site if that site is not representative of the whole paddock.

How do you measure it? – Level 2b monitoring

Key aspects of level 2b monitoring

Level 2B monitoring is consistent with the BioCondition Assessment Framework developed by the Queensland Department of Environment and Resource Management <http://www.derm.qld.gov.au/wildlife-ecosystems/biodiversity/biocondition.html>. The framework provides a means of assessing biodiversity at a patch, property or paddock scale that is compared to benchmarks for a particular vegetation type. A total of ten site-based attributes and three landscape-based attributes are assessed. For BioCondition Assessment, the following components of ground cover are measured: organic litter, native perennial and annual grasses, native non-grasses (herbs, forbs and others), introduced plants (weeds), rock cover, fallen logs and bare ground.

Skills needed

- Knowledge of local vegetation types and associated land management practices to allow you to determine suitable monitoring sites
- Ability to estimate ground cover percentage within a quadrat
- Basic maths and ability to use a computer spreadsheet for calculating average percentage cover at a site

Equipment

- Two steel posts for permanently marking the transect
- A 1 m by 1 m quadrat (can be made for minimal cost in the property workshop). To facilitate the estimation of percentage cover, the sides of the quadrat can be painted in alternate colours to divide it into 10 cm lengths. An open end allows the quadrat to be used where there are obstructions such as trees or shrubs.
- A camera
- GPS unit (optional)

Figure 9 shows an example of a quadrat recommended for use in monitoring for biodiversity.

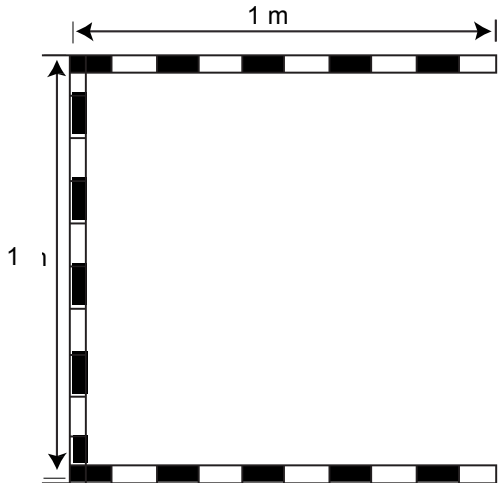

Figure 9: Quadrat recommended for use in measuring ground cover for BioCondition assessment

Time taken

- 30 minutes to locate and establish a monitoring site as illustrated in Figure 10.
- 15 minutes to take and record the ground cover observations and to take a photograph at each site

Setting up

To monitor for BioCondition Assessment, ideally all vegetation types and all areas subject to different levels of management on the property should be monitored for ground cover. The combination of a particular vegetation type and management action is called a zone. Some thought needs to go into the placement of your monitoring areas within these zones to minimise the number of sites but still ensure you represent the range of vegetation and management actions on the property.

Figure 10 shows the layout for a monitoring site used to assess the ground cover component for BioCondition Assessment. Ideally the transect should be across the slope and the photopoint should be the most northerly post.

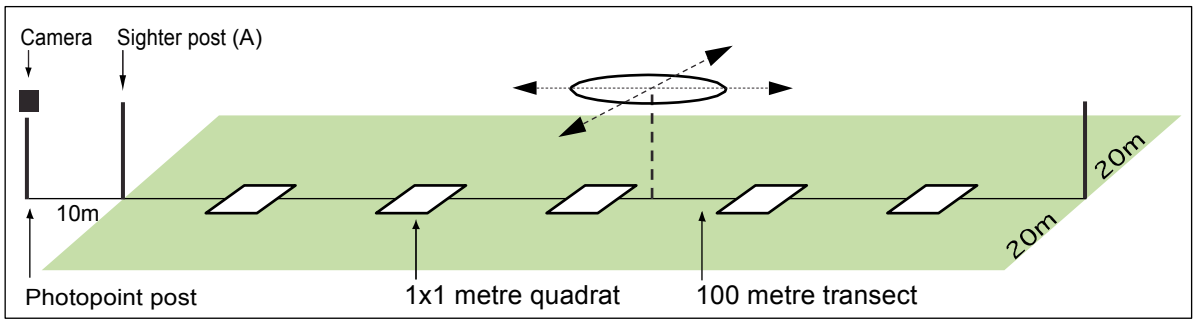

Figure 10: Standard monitoring site for BioCondition Assessment

The two end points of the transect should be permanently marked with, for example, steel posts. If using posts they should be made safe and visible to motor bike and horse riders (e.g. by attaching a piece of PVC pipe over the top or painting the posts white and placing a protective cap over them). On open areas such as Mitchell grass downs, it may be necessary to place some old tyres around the posts to alleviate the effects of stock gathering to rub on the posts and increasing stock pressure in the area. The location of each site should be numbered and marked on a property plan and/or GPS recordings should also be taken and entered into your GIS.

Monitoring procedure

1. Commencing at one end of the 100 m transect, walk a distance of 10 metres and place the quadrat in front of your leading foot and estimate the ground cover within the quadrat. You need to make separate ground cover assessments

for the following components:

- native perennial grasses
- native annual grasses
- native herbs and forbs (non-grass)
- native shrubs (less than 1 metre height)
- weeds
- litter
- rock
- bare
- fallen logs
- cryptograms.

Tip: Consider cover as being anything below your eye level that intercepts a raindrop that is falling vertically or mentally 'move' all of the cover to one corner of the quadrat and estimate the cover that way. Cover provided by low shrubs of less than 1 metre is included but not higher shrubs or tree canopies.

2. Record your estimated percentage cover within the quadrat on the relevant level 2b recording sheet. (refer also to 'How to record your results').
3. Continue walking along the transect making estimates with the quadrat every 20 metres until you have a total of five estimates
4. Take your landscape and trayback photographs at the photopoint. For biodiversity monitoring, you should also take four additional landscape photographs from the centre point of the transect, one each facing the four points of the compass (north, south, east and west). Make any relevant notes against your photographs.

How to record your results

The information you collect while monitoring is referred to as data. Data is distinct pieces of information (e.g. numbers, text or images) that can be stored electronically, on paper or as samples. An organised collection of data with a common theme is called a dataset. For example, a collection of data about a particular geographic area for a particular time period would form a dataset.

When you are working in the field, the simplest way to record your data is to have a field recording sheet with you. A field recording sheet will help ensure that your data is recorded in a way that is easy to enter into a spreadsheet and also acts as a checklist to ensure that you don't miss recording any important information.

'Recording sheets' for each of the different methods of measuring cover (Levels 1, 2a and 2b) are provided with this indicator material. Examples of completed recording sheets are also provided. Blank data sheets can be printed off for use in the field. Your data can be entered into the electronic version of the field recording sheet if you want to use the automatic totalling and averaging functions. You can also enter the summary data on to the data recording sheet for the long-term collation of your data and creation of charts.

Metadata

There are two aspects to recording information: the information (data) you collect each time you monitor and the metadata associated with your monitoring data. Metadata is pieces of information that describe data or is 'data about data'. It describes the 'who, what, when, where, why and how' about a data set. Metadata is critical to preserving the usefulness of data over time.

It is important to record the information shown in Table 1 below. This table is available in the spreadsheets that can be downloaded for each of the indicator levels in 'How do you measure it?'

Table 1: Typical data sheet for recording metadata that describes the dataset

Key element	Metadata
Short description of the contents of the dataset	
Name of the land manager or business responsible for the dataset	
Brief assessment of reliability of the information in the dataset	
Brief history of the source and processing steps used to produce the dataset	
Maintenance and update frequency of the dataset	
Location or area the data relates to	

What does your data mean?

Percentage ground cover can be highly variable and strongly influenced by the weather, seasonal growth patterns, land type and land use and management practices. Figure 11 provides an example of how the average cover levels may vary in a paddock (similar graphs can be produced from the spreadsheets provided in 'How to record your results' of this indicator. The annual rainfall has been added to the graph. Keep in mind that rainfall occurs sporadically and it is quite possible that a high proportion of the rainfall may have occurred in one or two months at the beginning, middle or end of the recording period.

A minimum level of 30–40% cover is required in order to ensure a reasonable level of protection from erosion and to perform the other ecological functions of ground cover as described in 'What is it?'. Higher levels of cover will increase the benefits that cover provides. In grazing lands the 30% to 40% cover level should exist at the beginning of the summer storm season. To achieve this, a surface cover level of around 70% is desirable at the end of the summer growing season.

Figure 11 shows the relationship between annual soil erosion and ground cover over 14 years at Greenmount on the Darling Downs. Figure 12 shows the relationship between ground cover and runoff as well as soil loss derived from 7 years of measurements on pasture land in Central Queensland.

Minimising soil erosion and runoff has important implications for water quality since runoff will usually contain sediment, nutrients and any agricultural chemicals that may have been applied to the soil (Finlayson and Silburn 1996).

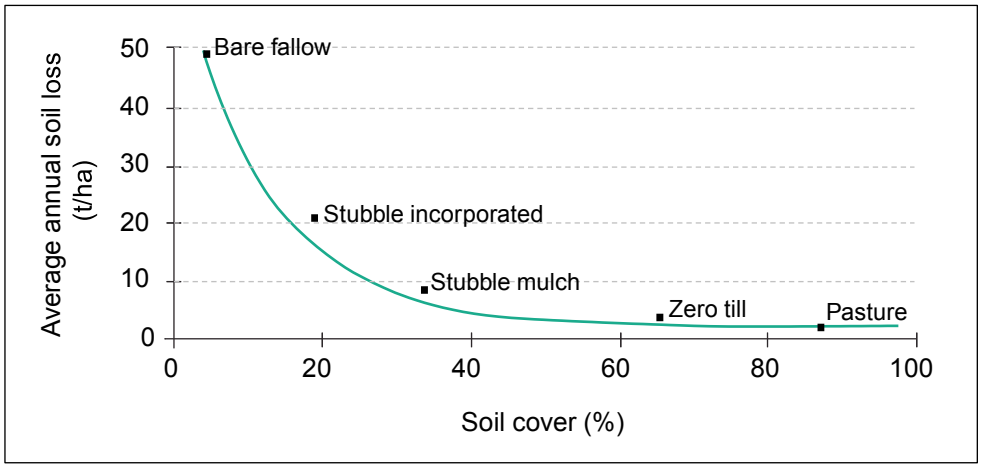

Figure 11: Annual average soil loss (1978–92) vs. cover for contour bay catchments on the eastern Darling Downs (Freebairn 2004)

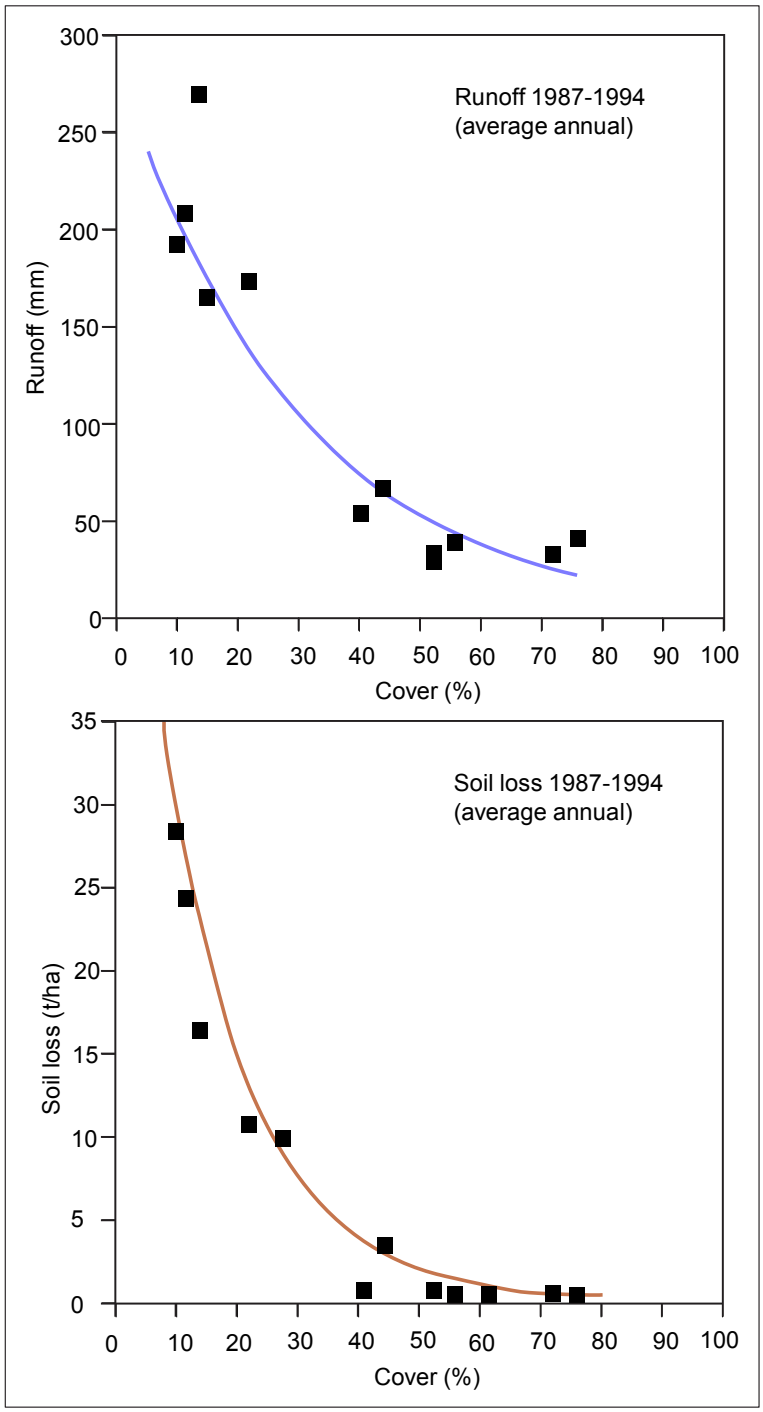

Figure 12: Average annual runoff and soil loss (1987–94) vs. ground cover for native pasture in Central Queensland (Mark Silburn, Queensland Department of Natural Resources and Water, pers. comm. 2005)

When monitoring for biodiversity values in the ground cover, your data would need to be compared with benchmark data prepared for the vegetation zone or regional ecosystem type you are monitoring. It is intended that this information will become available soon on the Queensland Department of Environment and Resource Management website. However, in general, to maintain ecological processes important for biodiversity, good ground cover (>50%) comprising litter, fallen logs and native plant species is the key. Litter and fallen logs provide habitat for ground-dwelling vertebrate and invertebrate fauna, as well as influencing soil microclimate, structure and composition.

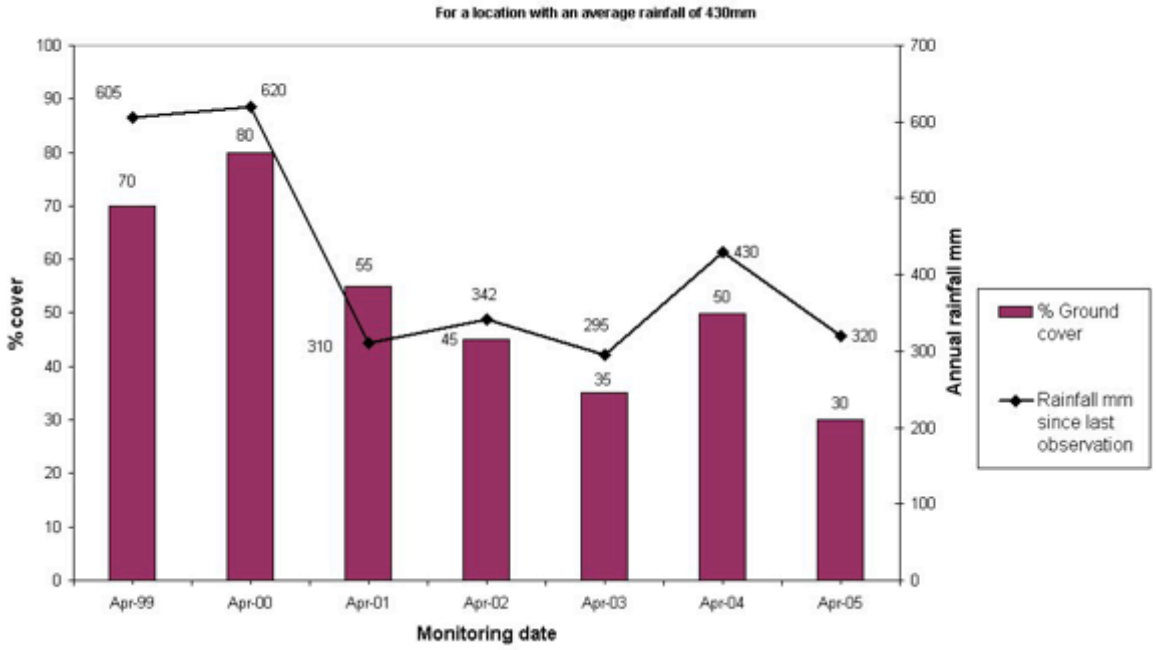

Figure 13: Rainfall and changes in pasture ground cover from 1999 to 2005

What are some management options?

These management options are only generalisations and should be interpreted with caution. It is important to remember that each situation is unique and so the most appropriate management option will also vary.

Grazing lands

Pastures need to be managed so that adequate levels of cover are maintained on the soil surface. Excessive grazing pressure, especially during periods of drought, leads to bare, vulnerable soil surfaces. The period of greatest risk is in late spring and early summer when cover levels are often low and rainfall intensities can be high. High grazing pressure also has an impact on both biodiversity and productivity because it can lead to pressure on the most palatable species, remove litter and lead to the introduction of weeds.

The data you collect and the charts you prepare, combined with your production records, can help you identify which paddocks or parts of a paddock are most productive and the conditions under which they maintain good cover. Your monitoring will also highlight the areas that lose cover quickly and require careful management.

Stocking rates should be based on the amount of grass in the paddock and the condition of the pasture, taking into account likely rainfall patterns for the next spring and summer. Seasonal forecasts including the Southern Oscillation Index (SOI) are a useful aid to management decisions at certain times of the year. A strongly negative SOI, especially in spring, can herald an El Niño and significant chance of drought; a positive SOI indicates a chance of wetter than normal conditions.

AussieGRASS (Australian Grassland and Rangeland Assessment by Spatial Simulation) is a simulation model developed to predict and to monitor historical grass production and land cover across Queensland and all Australian regions <http://www.longpaddock.qld.gov.au/rainfallandpasturegrowth/index.php>. At property or regional scale, maps from AussieGRASS output give the user a free monthly updated view of the current, historical and 3-month projected outlook of rainfall, pasture growth and grassfire risk. By taking account of livestock grazing by region, the pasture growth maps provide another valuable tool for producers to help base their decisions of stock and pasture management upon. These may include sites for stock agistment, buying and selling of produce and livestock decisions or status of pasture growth regionally or State wide.

As you increase your understanding of the responsiveness of your paddocks, you can begin to incorporate your results into your property management plan or farm management system by identifying different areas of your property according to their risk of developing low ground cover.

Strategies that can be used to respond to a poor seasonal outlook include heavy culling and sale, early weaning, agisting,

custom feedlotting and supplementary feeding. Regular planning includes stocking up with hay and supplements when prices are attractive. Some of these stockpiles can be used each winter to enhance normal management and replaced to ensure the reserves are always of good quality. Overdependence on supplementary feeding is an indication of excessive grazing pressure.

When assessing stocking rates the effects of native animals such as kangaroos and pests such as rabbits need to be considered.

Opportunistic spelling should be part of a grazing strategy. A total spell in a good summer season may be required to allow desirable grasses to recover from past overgrazing. Grazing pressure can also be managed by the location of watering points. They need to be located to minimise stock concentration in areas vulnerable to erosion.

Fire is a key tool for managing pastures and woody weeds but it needs to be managed carefully. Burnt pastures need to be spelled to allow around 20 cm regrowth before grazing. Your fire regime should be tailored to the land type, needs of the pasture species and any nature conservation considerations such as ground feeding or nesting birds. Burning too frequently may prevent pasture species from seeding or regenerating after drought or heavy grazing. No fire will allow regeneration of native trees and shrubs and woody weed species in cleared or naturally open country. A permit is necessary before burning and the conditions of the Vegetation Management Act need to be complied with.

The Queensland Department of Employment, Economic Development and Innovation provides a range of guides on management of specific types of pastures <http://www.dpi.qld.gov.au/27_7791.htm>. For more details check the reference Partridge (1992).

Graziers may wish to use the Stocktake package <www.dpi.qld.gov.au/stocktake>. It is a paddock-scale land condition monitoring method used as part of a grazing land management package recommended by the Queensland Department of Employment, Economic Development and Innovation. It has been developed to provide grazing land managers with a practical, systematic way to:

- Assess land condition and long-term carrying capacity
- Calculate seasonal forage budgets
- Integrate this information into a sustainable long-term production system.

Cropping lands

Crops need to be managed so that cover levels of at least 30–40% are provided throughout the year but especially during the summer months when there is a greater chance of high-intensity rainfall. After harvest, crop stubbles (referred to as ‘trash’ in the sugar cane industry) need to be retained on the soil surface, rather than being burnt or buried by tillage implements. Table 2 shows the amount of wheat or barley stubble cover removed by various tillage operations. The use of herbicides and specialised machinery has allowed the practices of reduced or zero tillage which result in maximum levels of ground cover retention.

Table 2: Estimated reduction in wheat or barley stubble cover from different farming operations (Department of Primary Industries and Fisheries brochure ‘Measuring stubble cover – Photostandards for winter cereals’)

Implement	Residue buried by each tillage operation	
	Fresh stubble	Old (brittle) stubble
Disc plough	60–80%	80–90%
Chisel plough	30–40%	40–60%
Blade plough	20–30%	30–50%
Boomspray	Negligible	Negligible

The term ‘opportunity cropping’ refers to the practice of planting a crop when sufficient soil water is available rather than according to a fixed rotation. It allows landholders to maximise surface cover levels.

Some non-cereal row crops such as sunflower, grain legumes and cotton provide inadequate levels of surface cover. Row spacings also affect the amount of cover provided by a crop.

Minimum tillage practices also apply to horticultural cropping. Cover crops can be grown during a fallow period to provide

protection from erosion as well as providing organic matter to improve the water-holding capacity of the soil. Cover may also be provided by using a surface mulch of plant residue from crops such as pineapples and bananas while in many tree crops a grass sod is recommended beneath the trees.

Urban areas

In an established urban environment, adequate ground cover should be provided by appropriate landscaping. Vulnerable areas will be land that has been disturbed while it is undergoing development and areas subject to high rates of pedestrian traffic on land that has not been given adequate protection (e.g. school grounds often have bare areas where high rates of runoff and erosion may occur).

A range of specialised products including hydromulching and geotextiles can be used to provide surface cover and to manage runoff on development sites. Disturbed land in urban areas is sometimes protected by fast-growing vegetation such as millet (summer growing) or oats (winter growing). These plants provide protection while the soil is in a loose and friable condition. When these annual crops mature, the remaining stubble will continue to provide some protection and by this time the soil will have consolidated and be less prone to erosion.

Protected areas

Private landholders can assist with maintaining biodiversity by providing a nature refuge on their property with assistance provided by the Queensland Department of Environment and Resource Management. A nature refuge is established via a voluntary conservation agreement between a landholder and the Queensland Government. A nature refuge is a category of protected area under the *Nature Conservation Act 1992*.

Each agreement is tailored to suit the management needs of the particular area and the needs of the landholder. In most cases, the agreement allows for the ecologically sustainable use of natural resources to continue. A nature refuge can cover part or all of a property protecting wildlife and wildlife habitat and emphasising the conservation of biodiversity as an important part of property management.

Other information sources

Books

Boulter, SL, Wilson, BA, Westrup, J, Anderson, ER, Turner, EJ, and Scanlan, JC (Editors) 2000, *Native vegetation management in Queensland – Background science and values*, Queensland Department of Natural Resources.

Tongway, DJ and Hindley, NL 2005, *Landscape function analysis – Procedures for monitoring and assessing landscapes, with special reference to minesites and rangelands*, CSIRO Sustainable Ecosystems.

CD-ROMs

Department of Primary Industries 2003, *Pasture Photo Standards CD*, Queensland Department of Primary Industries, .is available from the Queensland Government Bookshop <https://www.bookshop.qld.gov.au/> - Search for ' Pasture photo standards'.

PrimeNotes CD ROM Version 18 produced in May 2005 by the Queensland Department of Primary Industries and Fisheries contains over 5000 fact sheets about issues related to natural resource management and agricultural production. Fourteen agencies throughout Australia contributed information to the CD. This publication is available from some libraries.

Fact sheets

The Queensland Department of Environment and Resource Management has several fact sheets that are related to this topic:

- Soil limitation to water entry – understanding restrictive soil layers (L40)
- Erosion control in cropping land (L13)
- Erosion in school grounds (L42)
- Erosion control in grazing lands (L91)
- Managing for drought in grazing lands (L90)
- Identifying and monitoring salt-affected areas (L53)
- Catchments and water quality (C2)

Cater, D 2002, *The amount of stubble needed to reduce wind erosion*, Farmnote No 67/2002, Western Australia Department of Agriculture. <http://www.agric.wa.gov.au/objtwr/imported_assets/content/lwe/land/erosion/fn067_2002.pdf>

Journal articles

Molloy, JM and Moran, CJ 1991, Compiling a field manual from overhead photographs for estimating crop residue cover, *British Soil Use and Management Journal* 7, 177–83.

Websites

Landscape function analysis: A systems approach to assessing rangeland condition, CSIRO Sustainable Ecosystems web site < http://www.csiro.au/services/EcosystemFunctionAnalysis.html>

Stocktake – Grazing land management package, Queensland Department of Primary Industries and Fisheries <http://www.dpi.qld.gov.au/27_11643.htm>

Queensland Department of Environment and Resource Management fact sheets <http://www.derm.qld.gov.au/services_resources/item_list.php?category_id=123>

BioCondition Assessment Framework, Queensland Department of Environment and Resource Management <http://www.derm.qld.gov.au/wildlife-ecosystems/biodiversity/biocondition.html>.

Glossary

Fallen logs

Fallen logs refer to coarse woody debris or dead timber on the ground greater than 10 cm diameter and greater than 0.5 m in length.

Grazing pressure

This term refers to the amount of feed available compared to the rate of removal by grazing animals. The ideal stocking rate is flexible, so as to maintain a moderate grazing pressure most of the year and to match stock numbers to available feed. When assessing stocking rates, the effects of native animals such as kangaroos and pests such as rabbits need to be considered.

Ground cover

Ground cover is provided by plants (living or dead) and any parts of the plant that fall to the surface of the ground. Cover may also be provided by pebbles and rocks and 'crusts' formed by fungi, mosses, etc. In the urban environment, infrastructure such as concrete, bitumen and buildings may provide cover but their impermeability leads to high rates of runoff with consequent water loss and adverse effects downstream.

Herbaceous plants

Plants with soft, rather than woody stem tissues.

Infiltration

The movement of water from the soil surface into the soil profile. Surface cover assists infiltration by minimising raindrop impact and by retarding the flow of runoff across the soil surface. Soil characteristics affecting infiltration rates include surface seals, hard-setting layers, surface and subsurface compaction and impermeable subsoils. Infiltration rates are usually higher within plant tussocks compared to the area between tussocks because of the presence of plant roots and higher levels of biological life in this zone.

Litter

The ground cover provided in forests, woodlands and pastures by fresh or slightly decomposed leaves, bark, twigs, flowers and fruits. Litter is defined in BioCondition as including both fine and coarse organic material such as fallen leaves, twigs and branches less than 10 cm diameter.

Minimum tillage

A conservation tillage system in which the crop is grown with the fewest possible tillage operations. Herbicides and/or grazing may be used for fallow weed control.

Opportunity cropping

The practice of planting a crop whenever soil moisture reserves are considered sufficient, rather than according to a rigid rotational pattern. This leads to an increase in cropping frequency (e.g. two crops in three years) and greater levels of surface cover.

BioCondition Assessment Framework

The BioCondition Assessment Framework developed by the Queensland Department of Environment and Resource Management provides a means of assessing ecosystem condition for biodiversity at a patch, property or paddock scale that is compared to benchmarks for the particular vegetation type. It uses data from ten attributes to compile a dataset for conducting a BioCondition Assessment.

Rainfall erosivity

A measure of the capacity of the rainfall in a given location to cause erosion. It takes into account the combined effects of rainfall quantity and its kinetic energy (intensity). In most areas of Queensland, rainfall erosivity peaks in January–February and reaches a low point in August–September.

Raindrop impact

The result of the violent break-up and dispersion of raindrops when they hit the ground surface. If the surface is not protected, soil particles may be dislodged and scattered a considerable distance, due to the energy of the raindrop's impact. Dislodged particles are easily transported away by overland flow.

Stubble

The straw residue that remains after a grain crop has been harvested. It includes standing straw and that discharged by a harvester.

Stubble burning

A management practice in which the stubble from a crop is burnt after the harvest or prior to the sowing of the next crop. Stubble burning exposes the soil to erosion and destroys a potential source of soil organic matter.

Stubble incorporation

A management practice where stubble is incorporated into the surface soil by tillage, thereby promoting stubble breakdown and reducing the amount of protection that surface stubble can provide against erosion.

Stubble mulching

A conservation farming practice where stubble is retained on the surface of the soil by using suitable farm machinery such as chisel or blade ploughs. Implements such as disc ploughs are not suitable for stubble mulching since they incorporate an excessive amount of stubble into the soil.

Trash

Trash is the stubble remaining after the harvest of a sugarcane crop. The term 'green cane trash blanket' refers to a protective blanket of cane trash over the soil surface.

Zero tillage (or no tillage)

A minimum tillage practice in which the crop is sown directly into a soil not tilled since the harvest of the previous crop. Weed control is achieved by the use of herbicides and the retained stubble provides erosion control.

References

Department of Natural Resources 1997, *Grass check*, Publication DNRQ97002, Queensland Department of Natural Resources.

Department of Primary Industries 2003, *Pasture photo standards CD*, Queensland Department of Primary Industries.

Finlayson, B and Silburn, M 1996, 'Soil, nutrient and pesticide movements from different land use practices and subsequent transport by rivers and streams', in HM Hunter, AG Eyles and GE Rayment (eds), *Downstream effects of land use*, pp. 129–40, Department of Natural Resources, Queensland.

Francis, A and Payne, R 2003, *Field method for measuring soil surface cover*, Primary Industries and Resources SA fact sheet No. 8/01.

Freebairn, D 2004, Some observations on the role of soil conservation structures and conservation, *Journal of the Australian Association of Natural Resource Management* 7(1), 8–13.

Molloy, J 1988, *Field manual for measuring stubble cover*, Queensland Department of Primary Industries.

Partridge, I 1992, *Managing native pastures – a grazier's guide*, Information Series QI92009, Queensland Department of Primary Industries.

Tongway, D 1994, *Rangeland soil condition assessment manual*, CSIRO Division of Wildlife and Ecology, Canberra.

Authors

Bruce Carey and Andy Grodecki, Queensland Department of Environment and Resource Management.