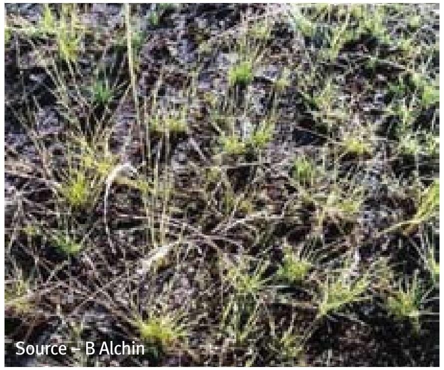
Source – B Alchin

Grazing BMP self-assessment
Soil health

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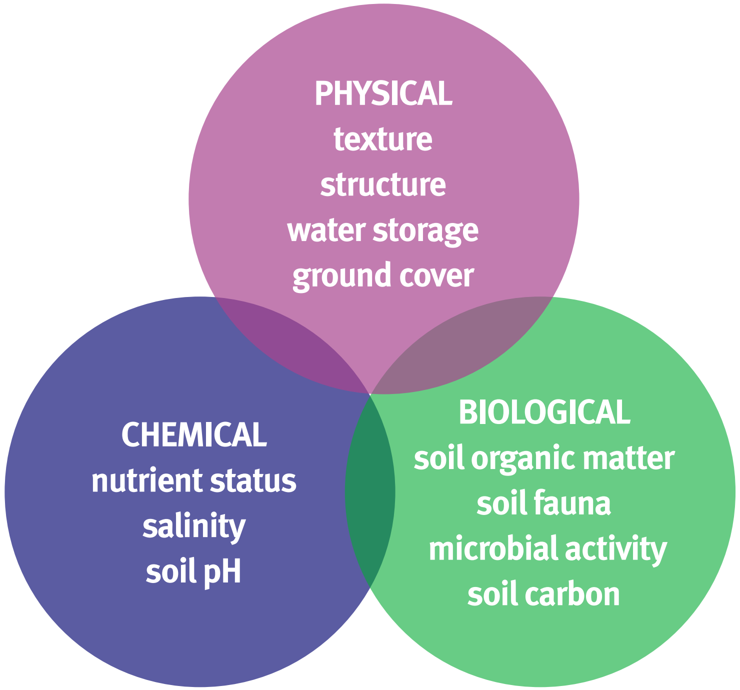
GRAZING BMP BEST MANAGEMENT PRACTICES

An example of a soil core

Self-assessment – **Soil health**

A healthy soil has effective nutrient cycling, good water infiltration and storage, and provides food and shelter for soil animals. Soil health is affected by and contributes to land condition; that is, the capacity of a landscape to respond to rain and grow pasture. A healthy soil on grazing lands is one that consistently produces pasture to the potential of each land type. Best management practices for grazing are those that manage our soils for sustainable long-term forage production.



The productive capacity and resilience of soils are determined by their inherent physical, chemical and biological characteristics and by how these characteristics are managed. Understanding the strengths and vulnerabilities of particular soil/land types, allows for better management decisions regarding grazing and infrastructure development to be made. This module has three key areas to address the physical, chemical and biological characteristics of soils. However, within the landscape these elements interact holistically and must be considered in relation to one another.

Key area 1. Soil physical properties

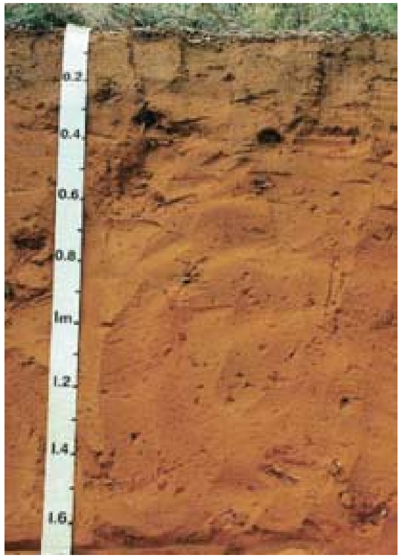
- Soil types
- Soil structure
- Dispersive soils
- Water storage capacity
- Maximising ground cover
- Restoring bare areas

Key area 2. Soil chemical properties

- Nutrient supply
- Fertiliser application
- Fertiliser run-off
- Salinity
- Soil pH

Key area 3. Soil biology

- Soil organic matter
- Soil organisms



An example of a sand profile. Highly permeable, excessively drained, retains only low amounts of water.

An example of a clay profile. Slowly permeable, imperfectly drained, retains high amounts of water.

Source – ASSSI 2008

Key area 1: Soil physical properties

The physical properties of a soil largely determine the ability of the soil to capture rainfall, store this rainfall and then supply water to the pasture or forage. Soil physical properties therefore influence how effectively pastures can grow, and can also affect the ability of plants to anchor themselves to the soil. Understanding the strengths and vulnerabilities of particular soil/land types, allows for better management decisions regarding grazing and infrastructure development to be made.

Soil types

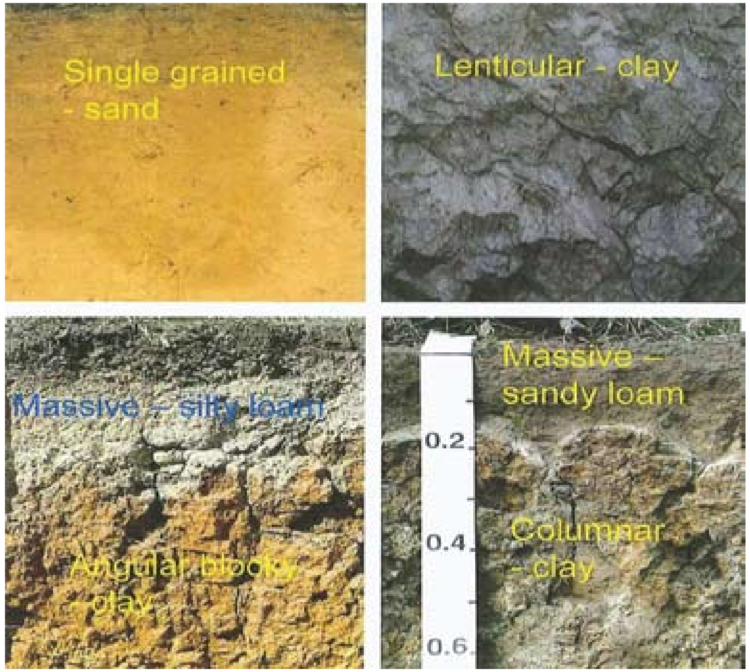
Soil types are referred to as sandy soils, loamy soils or clay soils reflecting their texture i.e. the proportions of sand, silt and clay they contain. Grazing properties and paddocks will often encompass a number of different soil types, each with inherent characteristics that can influence pasture growth and hence decisions about grazing management.

Extensive mapping of land systems and soil types in northern Australia has been conducted and so soil types on individual properties can usually be identified by referring to regional soil or land type maps, in combination with personal observation and experience.

Soil structure

Soil structure influences pasture growth by controlling the movement of water, nutrients, air and root penetration. Surface soil structure influences water infiltration, soil erosion (including scalding) and seedling emergence. Sub-surface soil structure influences soil aeration, water storage and root penetration.

The inherent structure of a soil is determined by the arrangement of the soil particles and the pore spaces between them. However, land use and the management of grazing, can also influence soil structure. Examples of areas with inherent or management-related poor soil structure are water-repellent sands, dispersive (sodic) soils, and areas that are compacted, waterlogged, pugged, bare or eroded. Soils with inherently poor structure are vulnerable to overuse by animals and machinery, resulting in loss of soil cover and compaction. Such areas need to be indentified and considered both in terms of grazing management and property improvements, to minimize a decline in soil health.



Examples of different soil structures Source – ASSSI 2008

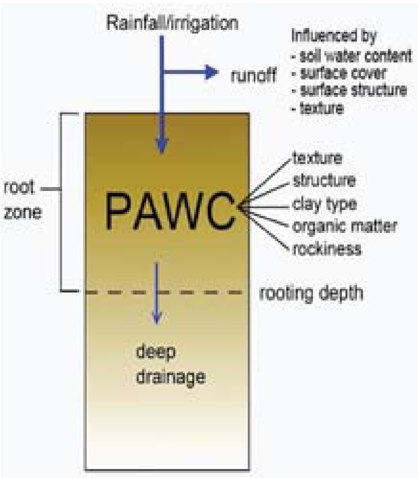
Gullying in a sodic texture contrast soil in the Taroom area

Source – ASSSI 2008

Dispersive ('sodic') soils

Soils with high sodium content have poor structure and are hard setting which reduces water infiltration. Lower water infiltration reduces plant available water and pasture growth is affected. These soils have 'dispersive' characteristics, meaning they 'dissolve' easily and are particularly vulnerable to sheet and gully erosion.

Sodic soils are best managed by maintaining healthy perennial pastures and good ground cover to protect the soil surface and maximise water infiltration. Because of the fragility of these soils they need to be considered when planning property infrastructure e.g. roads, fences, watering points and dam by washes.



The diagram displays plant available water capacity

Source – B Alchin

Water storage capacity

Soil water is the main limiting factor for pasture growth and animal productivity. The ability of a soil to capture and store water such that it is available for use by pasture for an extended period of time will depend on its inherent characteristics (soil texture, structure) in combination with its overall current soil health. Information about the speed with which different soils respond to rainfall and how long pastures can 'hang on' is useful when making pasture and grazing decisions.

Soil water holding or storage capacity is defined by upper and lower limits to the amount of water in the soil. The upper limit is field capacity – above this level water drains from the soil. The lower limit is **wilting point** – below this level the plants cannot extract water from the soil. The difference between water contents at **field capacity** and wilting point is the water storage capacity of the soil.

There are limitations on what can be done to improve soil water storage capacity. The key issues are:

- preventing loss of water storage capacity due to declining soil and land condition
- maximising water infiltration into the soil by maintaining healthy pastures and high levels of ground cover.

On soils which are prone to pugging and compaction, controlling grazing and spelling during wet periods helps to maintain infiltration.

Maximising ground cover

Ground cover refers to organic material and consists of senescent and green grasses, forbs, low shrubs, cryptogams and litter. Maximising ground cover is the most critical issue for soil health, land condition and maximising water infiltration.

High ground cover;

- minimises sealing and slows the movement of water over the soil surface, providing more time for water to infiltrate into the soil profile

- increases the biological activity and consequently the number of macro and micropores in the soil available for water infiltration.

Ground cover protects the soil surface from the erosive power of high intensity rainfall preventing loss of topsoil and even subsoil. The topsoil contains most of the organic matter and nutrients needed to grow good pastures, and also protects the more vulnerable subsoil. The protection provided by ground cover is particularly important for dispersive soils.

Ground cover guidelines indicate the minimum ground cover that should be present at the end of the dry season. These levels are designed to ensure the soil and landscape are adequately protected when the seasonal break occurs. Photo-standards provide a visual guide for assessing ground cover.

Soil erosion

Soil erosion occurs when soil particles are detached and transported elsewhere. There are three types of soil erosion – hillslope, gully and streambank.

High rates of hillslope erosion are likely to occur where:

- ground cover is less than 50%
- slopes are steeper than 2%
- rainfall is intense.

High rates of gully erosion are likely to occur where:

- catchment ground cover is less than 50%
- slopes around 2%
- soils with dispersible clay subsoils.

High rates of streambank erosion are likely to occur where:

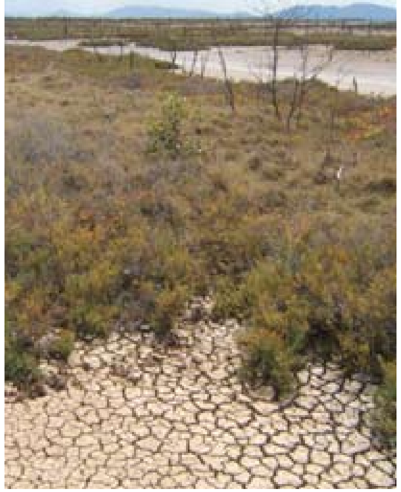
- stream velocities exceed 2 m/s
- there are rivers and large creeks
- riparian vegetation is sparse.

Sodic soils have the potential to erode easily Source – M Sullivan

Self-assessment – Soil physical properties

Below industry standard	Industry standard	Above industry standard	Desired standard	Steps required to improve
Soil types				
Soil types across the property are not known. ☐	Soil types on the property are broadly identified. The vulnerabilities of these soils types are known and used to guide management decisions regarding grazing and infrastructure. ☐	Industry standard plus: Soil and/or land type maps for the property have been created and management strategies based on these maps have been developed and implemented: e.g. fencing to soil type/land type; matching grazing pressure to land type and condition. ☐	Industry standard ☐ Above industry standard ☐	**1.** **2.** **3.**
Soil structure				
Soil structure is not considered in property planning and grazing management. ☐	Potential impacts of soil structure on erosion, compaction and water logging are known and considered when planning and implementing property improvements and grazing strategies. ☐	Industry standard plus: Strategies for addressing soils with poor soil structure and avoiding future risks have been developed and implemented. ☐	Industry standard ☐ Above industry standard ☐	**1.** **2.** **3.**
Dispersive soils				
Areas of sodic soils are not known or considered in making grazing or infrastructure decisions. ☐	The location of soils with dispersive characteristics on the property is known. Where these soils are present, this knowledge is used in making grazing and infrastructure decisions to avoid erosion and manage problem areas. ☐	Industry standard plus: Potential risk areas are marked on the property map, and infrastructure has been strategically placed. ☐	Industry standard ☐ Above industry standard ☐	**1.** **2.** **3.**

Below industry standard	Industry standard	Above industry standard	Desired standard	Steps required to improve
Water storage capacity				
The ability of different soils on the property to capture and to respond to rain is not considered in pasture or grazing decisions. ☐	Variation in the ability of different soils on the property to capture and respond to rain is known and considered in pasture and grazing decisions. ☐		Industry standard ☐ Above industry standard ☐	**1.** **2.** **3.**
Maximising ground cover				
No consideration is given to managing ground cover when planning grazing and land management. ☐	Grazing is managed to maintain ground cover at or above 50% (or as recommended for that land type) at the end of the dry season. ☐	Industry standard plus: Ground cover is assessed annually using photo monitoring sites (or an equivalent technique) and documented for all major land types to inform grazing management. Where available and appropriate remote sensing technology is used to monitor long term trends in ground cover. ☐	Industry standard ☐ Above industry standard ☐	**1.** **2.** **3.**
Restoring bare areas				
No consideration is given to restoring bare areas which have potential for increased ground cover. ☐	Bare areas with potential for improvement are identified and grazing and land management strategies are being implemented to improve ground cover. ☐	Industry standard plus: Bare areas are mapped. Recovery of bare areas is monitored using photo monitoring sites. ☐	Industry standard ☐ Above industry standard ☐	**1.** **2.** **3.**



Very saline clays support marine couch and samphire Source – ASSSI 2008

Key area 2: Soil chemical properties

Nutrient supply

Pastures need an adequate supply of soil nutrients to make best use of soil water, to grow quality feed for stock, and to ensure good ground cover. Pastures grow poorly if the soil cannot supply adequate amounts of these nutrients. While geology and soil development determine the total amount of nutrients in soils, in the short term the amounts of nutrients available for growth are largely determined by the breakdown of organic material and the subsequent release of nutrients. Nutrients are classified according to the amount that a plant requires, as macronutrients (e.g. nitrogen, phosphorus, potassium and sulphur) or micronutrients (e.g. iron, manganese, zinc, molybdenum and boron).

Plant growth will be restricted by the availability of the particular nutrient which is in most limited supply. For example, if phosphorus is in limited supply, then applications of other macro or micro nutrients will be ineffective unless phosphorus levels are increased to meet the plant's requirements.

Soil testing

Soil and land type mapping provides information on soil fertility and in most extensive grazing situations this information is all that is required for planning grazing management and property development. For long term monitoring of soil chemical properties and fertility the most useful tests are salinity, sodicity and organic carbon. The Walkley and Black method is the most appropriate test for organic carbon. As these soil properties, change slowly testing for monitoring would only be required every five to 10 years.

Where improved pastures are being sown, soil testing should be undertaken to ensure the soil is suitable for the proposed pasture species. Plant foliage is rich in nitrogen, sulphur and potassium, and these nutrients may become deficient where large amounts of forage and hay are removed from the paddock. In forage cropping and intensive pasture systems, soil tests are commonly used to assess the availability of soil nutrients.

When undertaking soil tests, it is important to used accredited laboratories and follow the collection instructions to ensure representative samples are obtained.

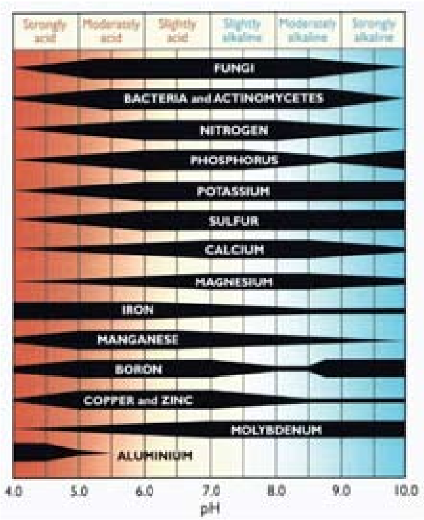
Fertiliser application and run-off

In higher rainfall intensive pasture systems and where forage cropping is undertaken, fertiliser application is often a critical part of management. Soil testing provides the information needed for deciding whether fertiliser is needed, and if so, which fertilisers to use and how much to apply. Test strips can be used to assess the response of pastures and forage crops to fertiliser application.

Application method, timing of application and proximity to waterways need to be carefully considered to minimize the risk of fertiliser loss and the movement of nutrients off-site. Fertiliser application is regulated in certain catchments.

Salinity

Soil naturally contains a range of different salts however when salts accumulate at a particular point in the landscape, pasture growth can be adversely affected. Soils associated with Brigalow ecosystems naturally contain high levels of salts,



– The table displays the effect of pH on nutrient availability and microorganism activity. Source – B Alchin

especially chloride. Saline areas can be induced where there is a particular combination of landform, soil type, and land management. The saline area (i.e. in a low-lying area) can develop at some distance from the land management that contributed to the salinity (i.e. tree clearing higher in the landscape).

Understanding the potential for salinity requires identification of areas in the landscape vulnerable to development of salinity. In areas where salinity is already an issue there will be dead or dying vegetation and areas of bare soil with salt crystals on the surface. Options for managing areas prone to salinity include lowering the water table by establishing perennial and deep-rooted vegetation upslope and salt-tolerant vegetation in the affected area.

Soil pH

Soil pH influences nutrient supply, plant growth and the soil's ability to grow desirable pasture species. Most pasture plants prefer soil pH above 5.5, however, soils in northern Australia range from strongly acid (<pH 5) to strongly alkaline (>pH 9). Higher pasture productivity generally occurs when the pH is slightly acid to slightly alkaline (pH 6-8).

Soil pH can change due to management practices; however, the extent of change is determined by soil type and rainfall. Sandy and loam soils can acidify relatively quickly (in terms of years or decades) compared to heavy clay soils which can take centuries for acidity to increase.

For example, pastures strongly dominated by legumes in sandy soils can increase soil acidity. As nitrogen is leached from the topsoil, both the topsoil and the subsoil can become more acidic. Acidification resulting from legumes can be mitigated by ensuring there is a balance in the grass-legume composition. The grass uses the nitrogen (produced by the legume), minimising nitrogen leaching from the top soil.

Deep-rooted perennial plants also reduce the effect of nitrogen leaching as their deeper roots can take up nitrogen moving through the soil profile before it moves past the root zone, and perennials can respond to rain earlier in the season than annuals.

Self-assessment – Soil chemical properties

Below industry standard	Industry standard	Above industry standard	Desired standard	Steps required to improve
Nutrient supply				
Nutrient status of the property's soil and or land types are unknown.	Nutrient status as indicated by land or soil type mapping is known for the property's soil and or land types and implications for grazing production are understood. Where appropriate, soil testing is undertaken to provide more detailed information on soil fertility i.e. for pasture development.		Industry standard Above industry standard	**1.** **2.** **3.**

Below industry standard	Industry standard	Above industry standard	Desired standard	Steps required to improve
Fertiliser application				
The use of fertilizer is not applicable on this property. ☐				
Fertiliser is applied without reference to objective soil test data or plant requirements. Relevant legislation and regulations are unknown. ☐	Fertiliser program is based on soil test data and plant requirements, and complies with relevant legislation and regulations. ☐	Industry standard plus: Fertiliser is applied following economic and nutrient budget assessments ☐	Industry standard ☐ Above industry standard ☐	**1.** **2.** **3.**
Fertiliser run-off				
Fertiliser use is not applicable to this property ☐				
No management actions are taken to minimize fertiliser run-off. ☐	Fertiliser application method and timing of application are chosen to minimize run-off. Particular consideration is given to sensitive areas, such as waterways, frontage land and high biodiversity areas. ☐		Industry standard ☐ Above industry standard ☐	**1.** **2.** **3.**

Below industry standard	Industry standard	Above industry standard	Desired standard	Steps required to improve
Salinity				
The existence of, or the potential for salinity to develop on the property has not been considered in development and management decisions. ☐	The potential for salinity to develop on the property is understood and management to reduce the risk of outbreaks implemented. Areas affected by salinity have been identified and strategies to manage these areas implemented. ☐	Industry standard plus: Potential salinity hazards and any current outbreaks are marked on the property map. ☐	Industry standard ☐ Above industry standard ☐	**1.** **2.** **3.**
Soil pH				
Soil pH is not known and/ or considered when making management decisions. ☐	Soil pH as indicated by land or soil type mapping is known for the property's soil and or land types and implications for grazing production are understood. Where appropriate, soil testing is undertaken to provide more detailed information on soil pH i.e. improved pasture development. ☐		Industry standard ☐ Above industry standard ☐	**1.** **2.** **3.**

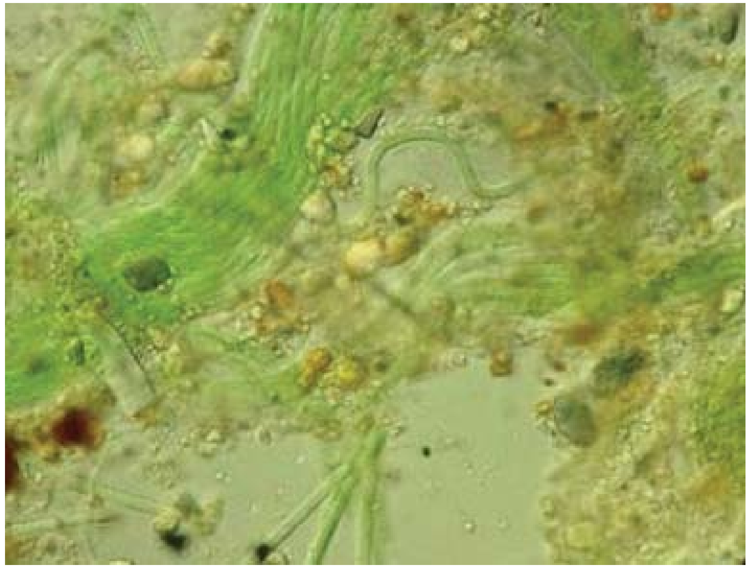
Key area 3: Soil biology

The living and dead biological components of the soil drive many of the processes that keep soils healthy, productive and resilient. About 85% of the biological component is made up of decomposing organic matter (plant and animal), 10% is live plant roots, and around 5% is in the form of living micro- and macro-organisms (soil biota). The microbiota includes bacteria, fungi, green and blue-green algae, protozoa and nematodes. The macrobiota includes earthworms, termites, dung beetles and other insects. In fertile soils, the biomass of micro-organisms alone can exceed 20 t/ha.

Soil organisms help maintain soil fertility and health by regulating nutrient cycling, maintaining soil structure and interacting with plants in the ecosystem. Healthy populations of soil organisms require adequate supplies of plant organic matter, which is their main source of food.

Soil organic matter and the population of soil organisms are maximised by growing strong pastures and maintaining high levels of ground cover. Soil organic carbon testing can be used to estimate organic matter levels.

Soil organic carbon levels are determined by the balance between the amount of dry matter grown and returned to the soil and the rate at which the organic material in the soil is broken down by microbes.



A microscopic view of Cyanobacteria, a micro-organism that forms biological soil crusts.

Source – B Alchin

Graziers can maximise soil organic carbon by growing productive pastures and maximising the return of organic matter to the soil. Much of this extra organic material will break down to benefit soils (support soil microbes, supply nutrients, maintain structure) but the remainder can improve soil carbon levels. However, soil type and climatic conditions determine how much carbon can be stored. In lighter soils, carbon is more easily broken down and the process is more rapid where there is more rainfall and heat.

Self-assessment – Soil biology

Below industry standard	Industry standard	Above industry standard	Desired standard	Steps required to improve
Soil organic matter				
The impact of ground cover and pasture condition on soil organic matter is not considered in grazing management. Recommended ground cover levels are not known and or maintained. ☐	Grazing is managed to maximise soil organic matter by growing productive pastures and maintaining ground cover at or above recommended levels for particular land types. ☐		Industry standard ☐ Above industry standard ☐	**1.** **2.** **3.**
Soil organisms				
The impact of ground cover and pasture condition on soil organisms is not known and/or considered in grazing management. ☐	Grazing is managed to promote soil fauna and microbial activity by growing productive pastures and maintaining ground cover at or above recommended levels for particular land types. ☐		Industry standard ☐ Above industry standard ☐	**1.** **2.** **3.**

References and further reading

General

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Key area 1 – Soil physical properties

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Key area 3 – Soil biology

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New South Wales Department of Primary Industries website, http://www.dpi.nsw.gov.au/agriculture/resources/soils/biology/soil-biology-basics