Northern Rivers Soil BMP Guide

Coastal Grazing

Best Management Practices for Soil Health

Landcare SoilCare Inc

Australian Government
Department of Agriculture, Fisheries and Forestry
National Landcare Programme

NSW DEPARTMENT OF PRIMARY INDUSTRIES

Northern Rivers CMA CATCHMENT MANAGEMENT AUTHORITY

Landcare Richmond Landcare Inc

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What is soil health?

Soil health in agricultural ecosystems is indicated by a living dynamic ecology providing the needs for healthy plants.

The components of these are:
- adequate air/water balance,
- micro and macro-organism activity and
- appropriate nutrient availability.

They are influenced by:
- soil texture and structure,
- mineral levels,
- organic matter cycling,
- topsoil depth and
- freedom from harmful substances.

Dave Forrest 2007

DICTIONARY OF TERMS

BIOTURBATION:
the mixing of soil organic matter into the soil profile by organisms.

BULK DENSITY:
the measure of how tightly packed soil particles are in soil. The higher the bulk density the lower the soil pore space.

CATION EXCHANGE CAPACITY (CEC):
the capacity of soil to hold nutrients for plant use. Specifically, CEC is the amount of negative charges available on clay and humus to hold positively charged ions. Effective cation exchange capacity (ECEC) is reported for acid soils (pH<5). Expressed as centimoles of charge per kilogram of soil (cmolc/kg).

COMPACTION:
compaction occurs when forces compress the soil and pushes air and water out of it so that it becomes dense.

C:N RATIO:
amount of carbon relative to the amount of nitrogen present in organic matter.

BANKS:
Contour bank:
an earth embankment that runs across the slope following the contour of the land, with a shallow channel on the upslope side. It is designed as a barrier to surface water flow.

Graded bank:
similar to a contour bank but designed to have very slight fall along the upslope drain channel. The grade is usually 0.1–0.5%.

Diversion bank:
specially designed bank with drain on the upslope side that diverts excess water from a sensitive area. It is graded but not usually more than 3%.

BIO BREW:
a bacteria and fungi rich liquid soil amendment.

EXUDATES:
soluble sugars, amino acids and other compounds secreted by roots.

GROUND COVER:
any plant or plant residue that covers the soil surface and protects it from erosion and moisture loss.

HUMUS:
organic matter that is so decomposed that it can no longer be recognised as individual components is known as humus. The highly complex compounds that make up humus are able to resist further decomposition, and therefore accumulate in the soil.

MINERALISATION:
biological process in which organic compounds are chemically converted to other simpler organic compounds or inorganic forms, such as ammonium or phosphate, by soil microorganisms.

MULCH:
any material that is placed on the surface of the soil.

ORGANIC MATTER:
anything that contains carbon compounds that were formed by living organisms. Examples include lawn clippings, leaves, stems, branches, moss, algae, any animal parts, manure, sawdust, insects, earthworms and microbes.

PARASITICIDES:
an agent that destroys parasites

PEDS:
clumps of soil that stay together as one structure when soil is disturbed with minimal force, such as with a shovel.

RESIDUAL:
remaining or left behind.

RIPARIAN:
the interface between a river or stream and land.

SOIL ECOLOGY:
the study of interrelations among soil organisms and between organisms and the soil environment.

SOIL FOOD WEB:
the inter-connected community of organisms living all or part of their lives in the soil.

SOIL ORGANIC MATTER:
the total organic matter in the soil. It can be divided into three general pools: living biomass of micro-organisms, fresh and partially decomposed residues (the active fraction) and the well-decomposed and highly stable organic material. Surface litter is generally not included as part of soil organic matter.

SOIL PH:
a measure of the acidity or alkalinity of soil. The scale range is from 0 (most acid) to 14 (most alkaline) with 7 as neutral. Soil pH can be measured in water or calcium chloride ($CaCl_2$). If pH is measured in water it is .5 to .8 higher than if measured in

INTRODUCTION AND BACKGROUND

INTRODUCTION

The **Northern Rivers Soil Best Management Practice (BMP) Guide – Coastal Grazing** has been developed by farmers for farmers. It offers practical guidelines to improve and maintain soil health for better production and environmental outcomes. The Soil BMP is a 'living' document and as such can be edited and updated as we further our understanding of soil processes in coastal pastures.

The BMP Guide supports the **Northern Rivers Soil Health Card – Coastal Grazing (SHCCG)**. The SHCCG provides 10 straightforward visual tests for landholders to assess soil health in the pddock using simple equipment and can be carried out by the farmer in the field. For information on how to obtain the SHCM refer to the 'WANT TO KNOW MORE' section of this document.

BACKGROUND

The Alstonville Plateau Landscape soil commenced production some 20 million years ago when Mt Warning ceased erupting. Under the high rainfall conditions the plateau soil weathered and leached and the rainforests, the 'Big Scrub', grew.

When the first European settlers came to the area they saw lush forests – a teaming biomass of vegetation – supported by the underlying red soil. Fertility and productivity in the Big Scrub depended on nutrient cycling. Nutrients were held in the organic matter on the forest floor which was recycled to the soil.

The prized plateau soils, known as Krasnozems or Red Ferrosols, are relatively high in organic matter (18–20%) in their natural state in rainforests. Nevertheless on clearing, organic matter declines rapidly to less than 7% within a few years and as low as 2 or 3% if the soil is cultivated and left exposed for long periods (Hungerford 1995). Once cleared these soils have diminished nutrient and organic matter levels compared to the original forested condition.

ALSTONVILLE PLATEAU LANDSCAPE SOILS

Krasnozems/Red Ferrosols formed from basalt parent material under conditions of high rainfall. They are red-brown to orange in colour depending on organic matter content, generally a well structured clay but with localised stoniness. The good structure facilitates high water infiltration, good drainage and aeration. They are commonly deep topsoils (2m+) but have poor chemical properties, e.g. low pH, trace elements and other minerals and nutrients.

Chocolate soils formed from basalt parent material under conditions of lower rainfall. Topsoils are shallow (<1m), brown to black in colour with a loamy clay or clay overlying a paler heavy clay. The subsoil is poorly drained. These soils have good mineral content, but with a high magnesium to calcium ratio making soil structure less stable.

Podsolic soils formed from sedimentary deposits of sandstone, mudstone or shale. The topsoils are shallow (75mm), highly erodible grey to brown loam overlying poorly structured yellow to red clay subsoils. They are infertile with low mineral content, low pH, poor structure and low organic matter.

Alluvial soils vary widely in their features depending on parent material. They are usually fertile because they are composed of eroded topsoil from catchment, but physical properties vary from well-drained loams to poorly structured clays.

Excerpted from Soil Landscapes of the Lismore-Ballina 1:100,000 Sheet

STRENGTHS & WEAKNESSES OF ALSTONVILLE PLATEAU LANDSCAPE SOIL

'STRENGTHS'

The greatest asset of the plateau landscape soil is structure. In good condition it has the following characteristics which makes it physically ideal for plant growth:

- loose and friable (A friable soil is well aerated and allows for good root growth.),
- high permeability to both air and water'
- reasonable ability to hold water that can be accessed by plants (plant available water content),
- low soil strength when moist (allows for easy root penetration in the soil).

This good physical structure allows water to infiltrate easily through the soil. It is not prone to water logging except in low lying areas. It also provides a favourable environment for soil biological organisms to flourish.

Nevertheless, if the soil is not protected it is moderately to highly susceptible to erosion depending on slope and rainfall. Also because of the mineralogical nature of the soil (i.e. the soil lacks minerals that allow it to shrink and swell) once it is structurally damaged, by compaction, for example, it is very hard to repair.
The plateau soil is not saline or sodic.

'WEAKNESSES'

The majority of the 'weaknesses' of the plateau soil are as a result of its formation and use under high rainfall conditions. The plateau soil is weathered and leached and consequently has the following characteristics:

- **Low soil pH:** Soil pH affects the availability of nutrients and chemical species to plant roots. The plateau soil is 'naturally', moderately to strongly acid and has the potential to induce:
  - aluminium and manganese toxicity; manganese toxicity, for example, affects the metabolism of plants causing yellowing and death of leaf tissue.
  - calcium, magnesium and molybdenum deficiencies once pH is below 5 ($CaCl_2$).
  - reduction in phosphorous (P) availability leading to less root growth and less ability for oil accumulation in the kernel.
- **Moderate to low ability to hold nutrients:** the 'mineral' soil, that is the soil without organic matter, humus etc, has a moderate to low cation exchange capacity (CEC), which means it has limited ability to hold nutrients. Low soil pH contributes to a low nutrient holding capacity. The CEC can be improved by the build up of organic matter and humus in the soil.
- **Low exchangeable Calcium (Ca) and Magnesium (Mg):** At pH below 5, Ca and Mg become deficient and plant growth will be limited as a result.

Soil pH will continue to drop particularly under acidifying conditions of high annual rainfall and use of acidifying fertilisers such as ammonium phosphate.

ISSUES FOR SOIL HEALTH IN COASTAL PASTURES

Alstonville Plateau Landscape soils have a variable history of soil erosion and other degradation issues due to prior land management practices. The area's high rainfall along with any current unsustainable farm management practices increases the potential for erosion and nutrient leaching.

THE MAIN ISSUES IN PASTURES THAT IMPACT ON SOIL HEALTH AND SUBSEQUENTLY PASTURE PRODUCTION ARE:

- loss of valuable topsoil and topsoil organic matter due to past and present management practices, i.e. clearing, cultivation and erosion.
- declining soil fertility if topsoil and soil organic matter decline or are lost.
- decreasing soil pH (less than pH 5 ($CaCl_2$) and associated toxicities (aluminium toxicity) and deficiencies (lack of calcium and magnesium and reduction in soil microbial activity) from leaching rainfall conditions and use of certain nitrogenous fertilisers.
- breakdown of soil structure by machinery operations, particularly when the soil is wet, and with high intensity rainfall.
- ???

Many of the past and ongoing issues for soil health can be remedied.
Some things I can change or influence as a farmer are:

- I can assess and monitor the health of my soil by utilising the tools such as the Soil Health Card.
- I can then determine, prioritise and manage the risks to soil health.
- I can maximise soil cover and minimise soil erosion.
- I can manage pastures to reduce impacts on the structure of the soil.
- I can improve plant nutrition by managing soil conditions (chemical, physical and biological) and use of fertilisers and other soil conditioners.
- I can provide soil conditions to encourage and promote beneficial soil organisms.

Considerations for soil health in coastal pastures.

- Carry out Soil Health Card tests to assess soil health.
- Take soil samples for laboratory testing.
- Determine the issues that impact on soil health e.g. ground cover.
- Develop a long-term soil management plan to address the issues.

BMP 1 – MANAGING SOIL EROSION

SOIL HEALTH CARD TESTS: GROUND COVER, INFILTRATION, SOIL STRUCTURE AND EROSION

WHY IS SOIL EROSION IMPORTANT TO ME AS A FARMER?

The topsoil has the best soil structure, contains most nutrients, and has the highest level of soil biological activity and root density. As such it needs to be protected and conserved for pasture productivity. Managing the paddocks to prevent erosion will maintain the production value of the pastures and the asset value of the land.

- Topsoil erosion may be incremental with only millimetres being removed in one event but over time the healthiest part of the productive capacity is removed.
- High rainfall events are typical of the region so proactive measures need to be taken.

Left: 100% ground cover protects against soil erosion.
Photo: J Eastwood

HOW DO I MANAGE SOIL EROSION?

1. DESIGN FARM LAYOUT TO MANAGE WATER FLOW AND MINIMISE THE POTENTIAL FOR EROSION.

Cattel tracks running downhill increase the risk of soil erosion. Photo: J Eastwood

Place fences to:

- Minimise vertical tracking on hills,
- Protect riparian zones,
- Provide for optimal stock and vehicle movement, i.e. laneways or avenues,
- Minimise erosion near water points,
- Encourage the movement of animals across paddocks to minimise erosion near water points

·Maintain riparian buffers (including a combination of herbaceous plants, trees and shrubs) adjacent to rivers, streams and lakes to act as a filter for eroded soil and other contaminants.

Maintain and fence riparian zones.
Photo: J Eastwood

Place watering points to:
- exclude stock from water courses and dams,
- use trough water where possible,
- avoid poorly drained areas.

2. ESTABLISH, MAINTAIN AND MANAGE GROUND COVER IN THE PADDOCKS.

Maintain living ground covers to provide the best protection against loss of soil. This will slow down run-off water after rain and allow water to infiltrate into the soil.

Manage grazing to maintain optimum plant cover and diversity.

The roots of living ground covers:
- are highly resistant to erosion,
- support soil structure,
- support nutrient cycling,
- support soil biology,
- provide a cushion/buffer against compaction by machinery,
- bind soil particles.

If using herbicide, use knockdown rather than systemic chemicals to leave the root system alive to hold the soil.

3. STOCK MOVEMENT

· Use practices that encourage the movement of animals across paddocks.
· Avoid overgrazing of pastures.
· Use practices that minimize the congregation of animals or the repeated trampling of animals on the same lounging area or pathway.
· Riparian areas should only be grazed using short-term intensive grazing practices and then only during spring and early summer.

Soil erosion is a pollution event for the waterways receiving turbid, nutrient- laden material.
Photo: NSW DPI

4. BE AWARE OF CURRENT ENVIRONMENTAL AND LEGAL RESPONSIBILITIES FOR:

Soil loss as laid out under:

· **NSW Protection of Environment Act**
http://www.austlii.edu.au/au/legis/nsw/consol_act/poteoa1997455/
· **NSW Soil Conservation Act**
http://www.austlii.edu.au/au/legis/nsw/consol_act/sca1938215/
· **Water Management Act**
http://www.austlii.edu.au/au/legis/nsw/consol_act/wma2000166/
· Approval or licence requirements to carry out certain types of earthworks.

BMP 2 – MANAGING SOIL STRUCTURE AND COMPACTION

SOIL HEALTH CARD TESTS: GROUND COVER, PENETROMETER, INFILTRATION, STRUCTURE

WHY IS SOIL STRUCTURE IMPORTANT TO ME AS A FARMER?

Good soil structure is one of a farm's greatest assets.

Good Soil Structure

Poor Soil Structure

Photos: I. Biggs

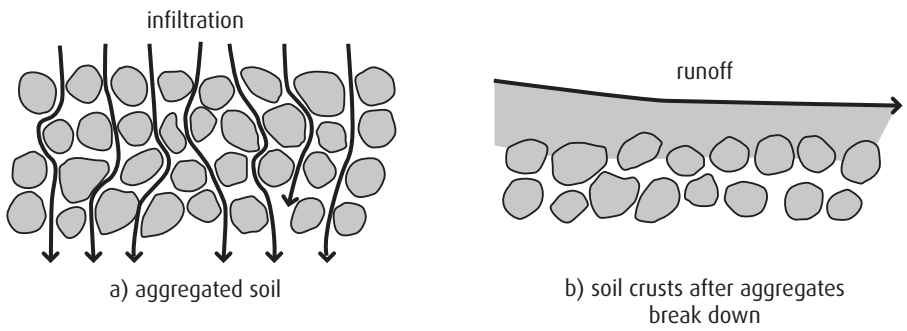
Soil compaction is a result of compressed structure which means:

- less air, water and root space is available. There are less sites for nutrient storage and there is less area for roots to access so plant nutrition (more fertiliser required) and plant growth are compromised.

- water storage within the soil is lessened as there is less space between the soil structural groups so the total volume that the soil can hold is depleted. The soil dries out sooner and can't hold as much in reserve when recharged.

- drainage rate is impeded in compacted soils so water moulds have longer periods of anaerobic conditions that favour their growth. Root rot limits nutrient and water uptake, so production is less.

- water infiltration rate is much lower so there is less water penetrating into the soil and more run-off, resulting in less effective rainfall. Surface compaction also increases slippage of machinery.



Changes in water-flow pattern due to soil crusting.
Excerpted from Building Soils for Better Crops, 2nd Edition, published by the Sustainable Agriculture Research and Education (SARE) outreach office, USDA.
For more information about SARE and sustainable agriculture, see www.sare.org.

Soil compaction reduces pores or spaces in the soil which restricts:

- plant root movement,
- water infiltration and storage,
- air circulation,
- nutrient availability,
- biological activity and
- plant health.

Left:
Photo:

HOW DO I MANAGE SOIL STRUCTURE?

1. MAINTAIN SOIL COVER TO MINIMISE EROSION.

- This is set out in **BMP 1.**
- Graze to optimal residue level for regrowth.

2. DESIGN FARM LAYOUT FOR STOCK MOVEMENT.

- Fence for pasture rotation.
- Rotational grazing reduces soil compaction.

3. MINIMISE IMPACTS OF MACHINERY.

- Limit usage of machinery to essential operations when the soil is moist, as soil structure is more easily compressed at those times. (See page 24 for simple test to assess soil compaction risk on wet soil)
- Plant vigorous ground covers to provide a buffering effect against compaction by machinery.

4. LIMIT HERBICIDE USE.

· Limit the frequency, type and area for herbicide application.

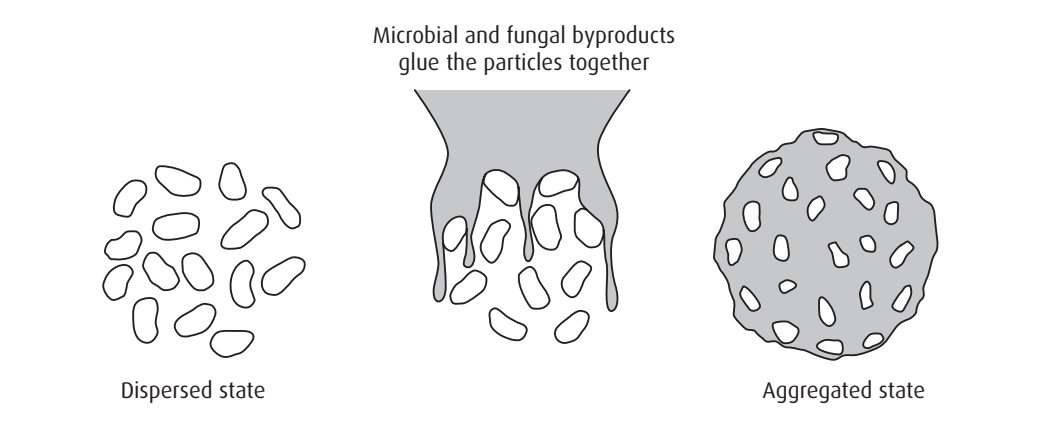
5. REHABILITATE SOIL COMPACTION LAYERS WITH ORGANIC MATTER ADDITIONS AND MECHANICAL TECHNIQUES.

· Allow deep rooting species that will help break up the layer.
· Maintain ground cover as it assists in rebuilding soil structure.
· Careful use of appropriate machinery such as aerator or chisel plough can increase aeration and improve compacted layers.
· Be aware that mechanical techniques to reduce compaction often give only temporary effects. A longer term option may be to instigate management practices that reduce the incidence of compaction.

6. PROMOTE SOIL BIOLOGICAL ACTIVITY.

· This is set out in **BMP 4.**

Soil fauna can have a major influence on soil structure by movement of soil particles during burrowing by larger species, mineralisation and incorporation of organic matter. The influence of soil fauna on the structure of soils may be local, such as within an ant nest or termite mound, or extensive, as by earthworms.

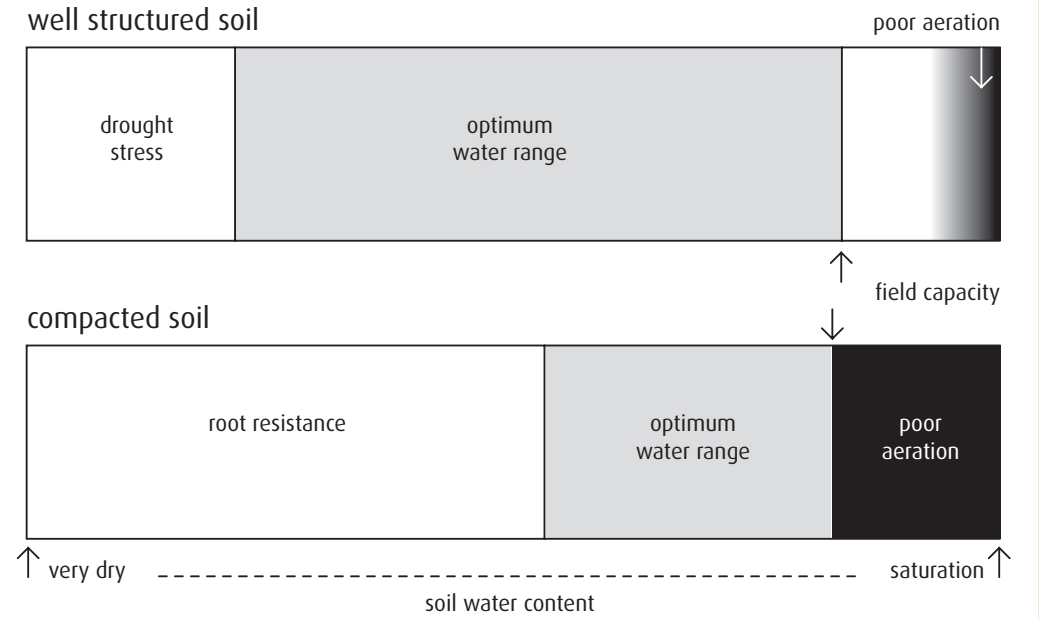


Soil biology provides many eco-services.
Microbial exudates glue soil particles to improve soil structure.
Excerpted from the ATTRA website: http://attra.ncat.org/attra-pub/soilmgmt.html

Increasing organic matter levels improves:

- soil structure,
- soil's ability to hold nutrients,
- water infiltration,
- water holding capacity,
- regulates soil temperature,
- biological activity.

The optimum range for crop growth for two different soils.



Excerpted from Building Soils for Better Crops, 2nd Edition, published by the Sustainable Agriculture
Research and Education (SARE) outreach office, USDA. For more information about SARE and sustainable agriculture, see www.sare.org.

BMP 3 – MANAGING PLANT NUTRITION

SOIL HEALTH CARD TESTS: GROUND COVER, DIVERSITY OF SOIL LIFE, ROOT DEVELOPMENT, SOIL PH, LEAF COLOUR

WHY IS SOIL MANAGEMENT IMPORTANT TO PLANT NUTRITION?

Pastures need a consistent supply of nutrients to maintain plant health and good production.

- High organic matter levels are necessary to maintain and increase nutrient storage and availability for general soil health and consequently for pasture production.
- Nutritional stress lowers energy availability for the tree. Yield falls proportionally to the level of stress.
- The ability of the roots to access nutrients is limited by topsoil depth, structure, soil moisture content, humus levels, biological activity, nutrient tie-up, nutrient presence and additions.

Left: Compost provides organic matter and nutrition. Photo: D Roby

HOW DO I MANAGE SOIL FOR PLANT NUTRITION?

1. DETERMINE SOIL AND PLANT NUTRITION REQUIREMENTS.

- Using the soil sampling guide (see Appendix 5), provide soil samples to a recognized soil laboratory for analysis.
- Conduct the Soil Health Card for Coastal Grazing(SHCCG) tests.
- Prepare a soil and plant nutrition plan based on laboratory analysis and Soil Health Card results.

2. INCREASE AND MAINTAIN HIGH LEVELS OF ORGANIC MATTER TO ENSURE MAXIMUM NUTRIENT CYCLING BY:

- increasing biological activity and biodiversity,
- increasing organic carbon levels,
- improving nutrient holding and exchange,
- improving root health due to better soil structure,
- improving water infiltration, holding and drainage,
- 'unlocking' phosphorus.

3. MANAGE SOIL PH

A major problem is soils becoming more acid. Studies have recorded a drop in pH from 6.3 to 4.3 in 4 years and eventually declined to 4.0 as a result of leaching and the acidifying effect of ammonium sulfate nitrogen fertiliser.

- Ameliorate low soil pH to improve activity of soil organisms. A high level of biological activity maintains minerals in the nutrient cycle; fungal hyphae are major stores of calcium. Good microbial activity ensures release of nitrogen and sulphur from organic matter.
- Maintain humus or soil organic carbon levels to buffer against fluctuation in pH and reduce aluminium toxicity.
- Supply calcium.
- Use appropriate forms of fertilisers to reduce acidification.
- Use with caution and in small amounts if using highly soluble acidic or salty fertilisers. They supply high levels of nutrient but can affect soil chemistry and biology negatively. This can lessen soil health by lowering existing biological biodiversity limiting the availability of nutrients in the soil.

At pH below 5.0 there may be:

- reduced microbial activity affecting release of nitrogen and sulphur from organic matter,
- high phosphorus fixation,
- reduced nodulation of legumes.

deficiencies of the elements:
- calcium
- magnesium
- molybdenum
- boron

toxicities of:
- aluminium
- manganese in solution

4. APPLY FERTILISERS AND SOIL AMENDMENTS APPROPRIATELY. MINIMIZE THE POTENTIAL FOR NUTRIENT RUNOFF.

- Apply fertilisers at appropriate times and under conditions that facilitate uptake without leaching. Leaching nutrient contaminates the water cycle and causes off farm problems.
- Do not apply fertilisers or soil amendments to saturated soil.
- Maintain fertility by replacing nutrients removed by leaching, nutrient fixation or product/stock leaving the farm.
- Compost manure to minimize pathogen populations.
- Protect the roots and soil from strong nutrient solutions. Root hairs can be killed by strong nutrient solutions and if leached they can leave the soil more acidic by combining with alkaline elements including Ca, Mg and K.
- Apply minerals such as calcium additions to improve soil structure by increasing grouping of clay particles. This also improves the soil pH for soil organisms increasing capacity for worm activity, whose tunnelling improves soil structure.
- Ensure phosphorus is available as it is an important mineral for soil organism energy metabolism.
- As part of a pasture nutrition program, bulk or pelleted poultry manure and compost provide organic matter as well as nutrients.
- Plant nitrogen (N) fixing leguminous ground covers. Legumes can supply a major amount of N requirements. Be sure to inoculate the seed.

5. BE AWARE OF SOIL MOISTURE CONTENT.

- Improve the water holding capacity of the soil with additions of organic matter carbon.
- Supplementary irrigation maintains soil biological activity and nutrient uptake into roots, minimising nutritional stress.
- Apply fertiliser under soil moisture conditions that facilitate uptake without leaching.
- Be aware of the optimum range of soil moisture for crop growth. See page 15.
- Avoid risk of nutrient leaching and promote efficient use of fertilisers with incremental applications.

BMP 4 – MANAGING SOIL BIOLOGY

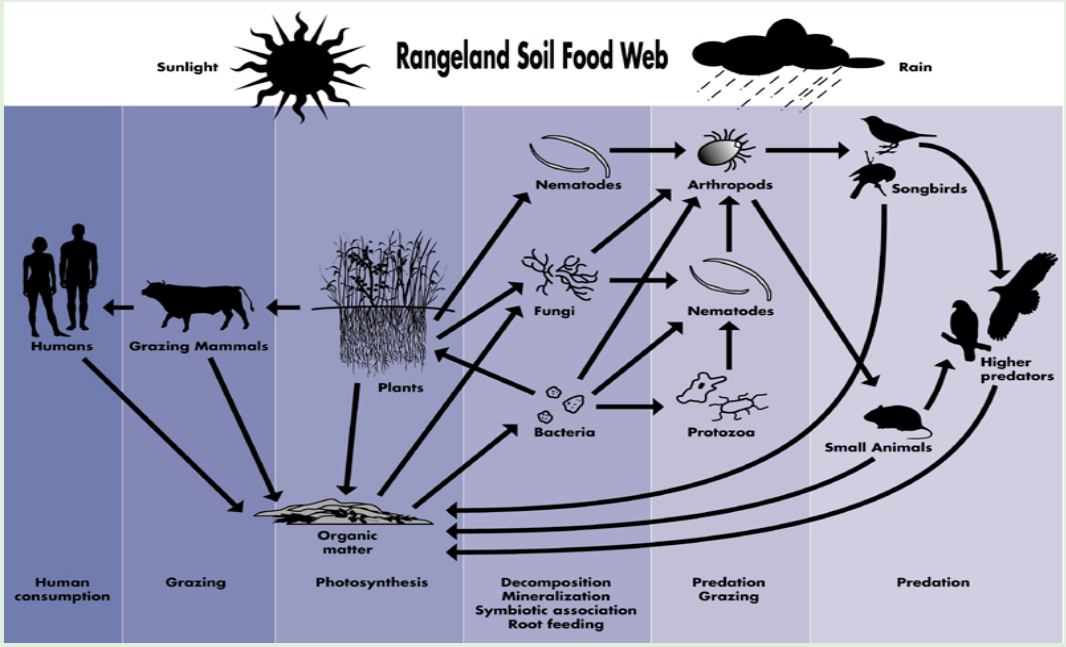
SOIL HEALTH CARD TESTS: GROUND COVER, SOIL STRUCTURE, DIVERSITY OF SOIL LIFE, ROOT DEVELOPMENT, EARTHWORMS, SOIL PH, BIO-TURBATION, CALICO STRIP TEST.

WHY IS SOIL BIOLOGY IMPORTANT TO ME AS A FARMER?

Soil organisms are nutrient managers.
They also determine many soil characteristics.

A diverse biological community sustains:

- decomposition of organic matter,
- nutrient cycling:
  - mineralization,
  - nutrient storage,
  - nutrient release,
- soil structure,
- root health,
- soil's ability to hold moisture,
- degradation of harmful chemicals,
- disease suppression.



Excerpted from NSTC Bureau of Land Managment 'Soil Biological Communities' [online].
Available: http://www.blm.gov/nstc/soil/foodweb/index.html (January 2009)

HOW DO I MANAGE SOIL BIOLOGY?

1. ENSURE SOIL IS PROTECTED BY GROUND COVERS.

- Ground covers maximise rainfall infiltration and preserve soil moisture.
- Ground covers regulate soil temperature to suitable range for organisms.
- Living ground covers trap carbon on site through photosynthesis and supply nutrients and energy from root systems and vegetative growth to soil organisms. i.e. soil bacteria fix nitrogen and so add it to the soil.

- Low organic matter (OM), soil compaction and high acidity in macadamia orchards contribute to low levels of biological activity.
- Biological activity moves organic matter down the soil profile.

Left: Note lack of OM movement down the soil profile.
Photo: I Biggs

2. BUILD UP AND MAINTAIN ORGANIC MATTER (OM) CONTENT.

- Vary the OM content. Composts, manures and mulches as well as on site material can significantly improve soil biological populations.

- Organic matter inputs can be increased through:
  - incorporating organic fertilisers into plant nutrition programs,
  - minimising herbicide use,

Healthy and diverse soil biological communities require:

- food from organic matter,
- root exudates,
- aerated soil structure,
- adequate minerals,
- adequate moisture.

3. REDUCE HARMFUL CHEMICAL USE, I.E. HERBICIDES AND PESTICIDES.

- Raised copper levels inhibit earthworm activity.
- High concentrations of nitrogen and chlorine in fertiliser inhibit fungi and other soil organisms.
- Use appropriate, strategic parasiticides, i.e. dung beetle friendly drench.

4. SUPPORT MICROBIAL ACTIVITY.

- Maintain plant growth to deliver energy to soil biology.
- Use supplementary irrigation, if available when soil is dry, to maintain the benefits of soil biological activity.
- Maintain pH in the desirable range. See BMP 3.
- Supply adequate inputs of calcium and phosphorus.
  - Calcium improves clay structure, pH, cation exchange capacity (CEC) and bacterial activity supporting a food chain which releases high levels of nutrients. Calcium is stored and released by fungal hyphae maximising retention in soil and availability to plant roots.
- Phosphorus is the mineral basis of all energy storage and use in plant and animal cells.
- If necessary consider using bio brews or compost to inoculate or feed soil biology.

NSW DPI SUGGESTED DUNG BEETLE MONITORING PROGRAM - PRIMEFACT 442 (SEE 'WANT TO KNOW MORE' PAGE 27)

- Monitor the dung beetle population once a month. This should be sufficient for you to understand what is happening on your property.
- Rate dung beetle activity as 'nil', 'low', 'medium' or 'high'. 'Nil' means that no activity is seen in dung pads, and 'high' means that most pads are rapidly dispersed.

To estimate the number of each species of dung beetle present, proceed as follows:

- Look for dung pads 1–2 days old and preferably showing evidence of dung beetle activity, such as disturbed soil at the edge of the pad ('yesterday's' dung is fine – this is to ensure that day-fliers and night-fliers will be present). Approach quietly, as dung beetles are sensitive to vibrations and will quickly descend down their tunnels.
- Shovel up two dung pads into a bucket, taking about 25 mm of soil from under the pad.
- Fill the bucket with water and stir well with the shovel to break up the dung. The dung beetles will float to the top – skim them off with a sieve. Stir again, skim again, and continue until you get no more beetles. You can collect more dung pads and repeat the procedure if you like.
- Count the number of each species of dung beetle present.

You could do less detailed monitoring and still get an idea of what is happening on your property.

5. REVIEW PASTURE MANAGEMENT PRACTICES.

- Soil biology responds to the provision of food supply from pasture and animal residues
- Deep rooting species deliver this nutrition down the soil profile.
- Misuse of fertiliser that is acidic, salty or contains chlorine gives a short term gain but long term loss.
- Manage residual pasture for soil biology.

Appendix 1

BMP 2 – SOIL STRUCTURE – ADDITIONAL INFORMATION

A lump of soil when broken in the hand, generally results in natural aggregates or 'peds'. The size and shape of the peds are the aspects of the soil structure.

Soil structure is the way the soil particles, sand, silt, clay and organic matter are arranged and the size and shape of gaps and channels (or pores) between them. The pores provide the space for air, water, roots, soil fauna and flora.

Exposed plateau landscape soils on macadamia orchards are affected by:

- run-off that causes sheet and gully erosion,
- concentrated stem flow (water running down the trunk during heavy rain) which erodes soil,
- impact of raindrops and large water droplets falling through the canopy that can shatter soil peds and dislodge soil particles,
- loss of organic matter,
- compaction by machinery and use of other equipment such as blowers, etc.

Compaction, erosion, and declining organic matter levels all degrade soil structure, which results in:

- reduced rain fall infiltration resulting in increased run-off and erosion,
- reduced soil porosity, aeration and water storage.
- poor drainage and reduced trafficability,
- reduced root growth,
- declining yields,
- creation of a hostile soil environment for soil organisms.

A simple test to determine if soil is too wet to allow traffic or cultivation without risk of compaction.

Rapidly squeeze a small lump of soil into a ball and try to roll it into a rod about 3 mm in diameter. If you can make a rod easily, the soil is too wet and will compact if it is worked or has animals or machinery on it. If you can just make a crumbly rod the water content should allow traffic and cultivation without compaction. If you can't make a rod at all, the soil could be too dry for tillage in a sandy or loamy soil. You need to do this test at several points over the full depth of any proposed cultivation.

From the Soil Sense leaflet 1/94. Agdex 510 produced by Rebecca Lines-Kelly, formerly soils media officer, Wollongbar Agricultural Institute, for NSWA and SCS, north coast region, under the National Landcare Program, September 1994.

http://www.dpi.nsw.gov.au/agriculture/resources/soils/structure/compaction

Appendix 2

BMP 3 – MANAGING SOIL FOR PLANT NUTRITION – ADDITIONAL INFORMATION

The plateau soils are generally low in nutrients, have a low cation exchange capacity (low ability to hold nutrients) and low pH with a number of associated mineral toxicities and deficiencies. Also organic matter levels have declined to low levels where land has been cleared.

High organic matter levels are necessary to maintain and increase nutrient storage and availability for general soil health and for macadamia production.

Phosphorous (P) availability is reduced in krasnozem/ferrosol soils due to the high free iron content of the soil. Acid phosphates such as super phosphate are locked up very quickly by the soil with only a 5 – 10 % recovery.

The form of P available from compost and animal manures is in an organic form. Slow release of these manures is less prone to being locked up by the soil. Also release by soil biological process maintains nutrient availability.

Soil tests and plant diagnostic techniques (leaf testing) are the best way to match fertiliser requirements. Not enough fertiliser means nutrient deficiency. Too much fertiliser can also reduce yields, and more importantly pose serious environmental risks and waste money.

Ensure nutrient cycling is maximised by increased organic matter content and increase in beneficial biological activity.

Trials using composted macadamia husk and chicken litter have shown improvements in microbial activity and water holding capacity in degraded macadamia soils. Nutrient availability and fertiliser use efficiency is increased as organic carbon levels rise in the soil.

Use ground cover, mulch and compost to increase the organic matter content of the soil and create a soil environment that is supportive of soil organisms.

Appendix 3

BMP 4 – MANAGING SOIL BIOLOGY – ADDITIONAL INFORMATION

Soil organisms can represent 3% of the dry matter in your soil. A single teaspoon can contain tens of thousands of different species of organisms. They include bacteria, fungi, mites, ants, millipedes, beetles, earthworms, slugs and snails. Most of these are beneficial organisms and they actively manage or out-compete soil borne diseases/pests.

Soil organisms derive their energy and nutrients from breaking down plant and animal material. When digesting this material they release oxygen and mineral nutrients that plants can use. When the soil organisms die they decompose and release more nutrients, so are valuable contributors to soil fertility.
Soil fauna can also have a major influence on soil structure by movement of soil particles during burrowing by larger species, and mineralisation and incorporation of organic matter. Many soils under rainforest and wet sclerophyll forest in Tasmania, for example, have been found to consist entirely of earthworm casts and burrows. (Laffan, Kingston 1997)

Soil animals require certain soil conditions to grow and survive. Soil organisms need large supplies of organic matter for energy. They also need warmth (but not extreme heat), moisture, oxygen and a near-neutral soil pH.
Agriculture production activities generally make soils less healthy and therefore less conducive for soil organisms. These activities decrease the diversity of soil animals (number of species) and soil community structure. Agricultural practices change soil conditions, making it harsher for some soil organisms. Changes include the following;

- Soil moisture is decreased.
- Soil temperatures rise with greater fluctuations.
- Less organic matter is in the soil and often only from one or two plants rather than a range.
- Soil pH becomes more acidic.
- Soil is often disturbed by erosion, vehicle traffic and tillage which removes organic matter (Above information sourced from **www.soilhealth.segs.uwa.edu.au**)

In macadamia orchards, studies (**Healthy Soils in Macadamia Orchards**, Van Zwieten, see page 29) have demonstrated there have been significant declines in soil carbon content and increase in soil bulk density with decreases also in microbial activity, earthworm numbers and soil biomass in general. The same studies also showed that macadamia orchards have fewer earthworms than control plots and other subtropical production systems sampled.
Trials using composted macadamia husk and chicken litter showed improvements in microbial activity and water holding capacity in degraded macadamia soils (Van Zwieten et al). A survey of macadamia roots in a local mulch trial also found a good association between healthy trees, increased fibrous roots and mulch. This was found to be the most effective treatment in ameliorating macadamia dieback.

Appendix 4

HOW TO TAKE A SOIL SAMPLE FOR LAB ANALYSIS

NSW DPI guide to collecting soil samples for lab testing.

Checklist:

- Plan your soil testing with your local District Agronomist, Horticulturist or advisor.
- Collect samples with clean equipment.
- Send samples to the laboratory as soon as possible after collection.

Tools required for sampling:

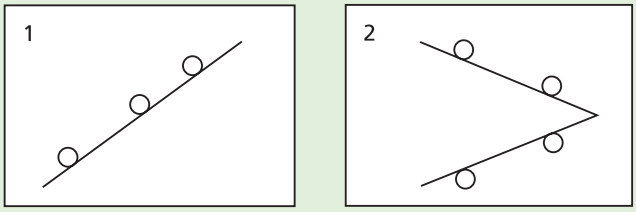
- Soil corer or spade
- Buckets
- New plastic bag or sample container (located in soil kit)
- Labels if more than one sample is collected
- Record sheet to record sample site and sample.

Remember a soil test is only as good as the care taken in sampling. Tools and equipment should be clean prior to sampling.

Taking a soil sample

- Look at the soils in the area you intend to sample. Submit a separate soil sample from each soil type (e.g. clay, loam or sand) and from paddocks that have been managed differently, because these factors affect fertiliser needs.
- For each sample, thoroughly mix a minimum of 20 soil cores (see following paragraph) in one bucket (the more cores taken the more reliable the sample). Fill the container supplied in the kit with the sample from the bucket. If you have collected multiple samples you can submit your samples in 500 gram bags to the laboratory. Make sure samples are clearly labelled.
- Soil cores should be collected at 0–10 cm depth. Avoid collecting the surface material such as leaf or organic matter. Deeper cores may need to be taken for the investigation of subsurface acidity and salinity or for larger horticultural crops (please contact your advisor for this advice).
- Once the samples have been collected they should be sent as soon as possible to the laboratory for analysis.

A map and written plan of the soil sampling area is essential for interpreting results and any subsequent testing. It is recommended that soil cores be collected along a fixed transect (e.g. 1 and 2). This method allows for re-testing and better monitoring of changes in fertility than random sampling. In areas where tree crops are planted samples should be collected along rows.



To obtain representative samples, do not sample from unusual sites such as: stock camps, manure patches, gateways, dams or water troughs, feedout areas, old fertiliser stockpiles, paddocks that have had fertiliser applied in the last 3 months.

WANT TO KNOW MORE?

Northern Rivers Soil Health Card for Coastal Grazing and **Soil Best Management Practice Guide for Coastal Grazing** are available to download from the following websites:

SoilCare Inc http://www.soilcare.org
Tuckombil Landcare http://www.tuckombillandcare.org.au

GROUND COVERS

DPI 'Soil Erosion Solutions Fact Sheet 4: 'Groundcover'
http://www.northern.cma.nsw.gov.au/pdf/groundcover.pdf

SOIL BIOLOGY

Soil biology basics is an information series describing basic concepts in soil biology.
http://www.dpi.nsw.gov.au/aboutus/resources/factsheets/soil-biology-basics

Dung Beetles - Working for You, NSW primefacts 442
http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/110171/dung-beetles-working-for-you.pdf

The Importance of Dung Beetles Website - http://www.faunanet.gov.au/faunakeys/coleoptera/dungbeetles/dungbeetles/html/generalinfo.html

Soils Are Alive, University of Western Australia – Professor Lyn Abbott
http://www.soilhealth.segs.uwa.edu.au/soil_biology

Earthworm management on NSW Northern Rivers' farms -
http://www.tuckombillandcare.org.au/projects/Worminformationflyer3-230506B.pdf

Fungicides and Soil Health - http://www.tuckombillandcare.org.au/projects/Fungicides%20and%20Soil%20Health.pdf

How to encourage soil organisms
http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/41637/Soil_organisms.pdf

Life in the Soil – CSIRO
http://www.csiro.au/files/files/pcz9.pdf

Soil Biology Primer
http://soils.usda.gov/sqi/concepts/soil_biology/biology.html

Soil Ecology and Management
http://www.safs.msu.edu/soilecology/soilbiology.htm

Soil Biology movies:
http://www.agron.iastate.edu/~loynachan/mov/

GENERAL SOIL INFORMATION

Soil Quality Publications – US Dept of Agriculture
http://soils.usda.gov/sqi/publications/publications.html#flyers

DPI Agnote: 'How to compost on farm'
http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/166476/compost-on-farm.pdf

Soil Health.Com – general soil information with emphasis on soil biology
http://www.soilhealth.com/

NSW Department of Primary Industries publications available from:
Phone 1 800 028 374
http://www.agric.nsw.gov.au

Website: NSW DPI - Pastures and Rangelands
http://www.dpi.nsw.gov.au/agriculture/field/pastures

Ag-Facts/Ag-Notes
http://www.dpi.nsw.gov.au/aboutus/resources/factsheets/agfacts_and_agnotes

Prime Fact Notes
http://www.dpi.nsw.gov.au/aboutus/resources/factsheets

Highly recommended books for basic soil information.

SOIL SENSE – NSW DPI Publications (order on-line)
http://www.agric.nsw.gov.au/reader/soil-sense-north-coast

Discovering Soils Series, CSIRO Publishing (order on-line)
http://www.publish.csiro.au/nid/22/sid/15.htm

OTHER RESOURCES

Abigail Jenkins, NSW DPI Soil Advisory Officer, Wollongbar

North Coast TAFE – Wollongbar, Sneaths Road, Wollongbar, NSW
(ph 02 6620 4200) Contact the Agriculture Section (Block 'D') for information on soil classes and other agriculture courses.

The most reliable sources of information on-line will be found at university and government sponsored web-sites. Suggested words and phrases for search engines: soil biota; soil organic matter; soil organic carbon; soil organisms; soil ecology; soil quality; soil health; soil fauna; earthworms; nutrient cycling.

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For more information about this document contact: info@soilcare.org

Download Northern Rivers Soil Health Cards and Soil Best Management Practice Guides at:
SoilCare Inc http://soilcare.org
Tuckombil Landcare http://www.tuckombillandcare.org.au

Disclaimers: The information contained in this publication is based on knowledge and understanding at the time of writing (2008). However, because of advances in knowledge, users are reminded of the need to ensure that information on which they rely is up to date, and to check the currency of information with the appropriate officer of NSW DPI or the user's independent adviser.