

# 1. Introduction

This soil health card was developed for the Northern Rivers Region of NSW as an extension activity of the Good Soils Project, a joint undertaking of Tuckombil Landcare Inc and NSW Agriculture in partnership with the Natural Heritage Trust.

The card was developed through a series of workshops held at Wollongbar TAFE. Primary producers representing a range of industries and one urban gardener attended the workshops. The process was facilitated by staff of Wollongbar TAFE and NSW Agriculture. Participants are acknowledged individually on the back of the health card folder. The aim was to develop a practical tool that all landholders in the Northern Rivers Region can use to monitor the health of their soils. As the core of the card, the team came up with a list of 10 straightforward visual tests that require simple equipment and can be carried out by one person in the field.

The soil health card lists the 10 tests and provides space for you to rate your own soils after carrying out the tests. By testing regularly and keeping the cards, you can build up a record of your soil health, and understand the effect of management practices on soil health.

Regular testing will show improvements in response to more sustainable management such as use of mulch in orchards, or minimum tillage in crop rotations, and allow early detection of developing soil problems. Test results can also be used as the basis for discussion about management changes with other landholders and with agricultural advisers.

This card is not intended to replace any soil testing that you may already carry out. It is another tool to help you understand your soils and their productivity. Maintaining soil health in the short term will undoubtedly increase the sustainability of farming into the future.

***'A basic soil audit is the first and sometimes the only monitoring tool used to assess changes in the soil. Unfortunately, the standard soil test done to determine nutrient levels (P, K, Ca, Mg, etc.) provides no information on soil biology and physical properties. Yet most of the farmer-recognized criteria for healthy soils include, or are created by, soil organisms and soil physical properties. A better appreciation of these biological and physical soil properties, and how they affect soil management and productivity, has resulted in the adoption of new soil health assessment techniques.'***

**National (USA) Sustainable Agriculture Information Service**  
**<http://www.attra.ncat.org>**

## 2. How to use your soil card

### 1. Read all the information first. This will help you go out into the paddock ready for action.

### 2. Prepare your equipment.

You will need to make 3 simple pieces of test equipment, using the instructions on Sheet 4, and gather together all the other items listed in the equipment list on page 3.

### 3. Decide where you will test.

We recommend you start with two sites, one to represent your 'best' soil and the other your 'worst' area. This will give you a good overview of how the tests relate to soil conditions on your land. You can then select other areas to get a broader understanding of the health of your soil.

### 4. Decide how many cards you need.

At each site you select, you may want to use more than one card if

- there is more than one soil type within the selected area
- conditions under row crops are quite different in the inter-row (eg light, groundcover, traffic)
- conditions in the paddock are quite different along the fence line (eg stock trampling, cultivation); completing one card for each situation will provide an interesting comparison.

### 5. Carry out the tests.

Each card lists the 10 tests and has space on the back for you to draw a sketch map of the site and show the test sites. Once you are familiar with the tests it will take you around 20 minutes to carry out one set of tests. Each card has room for you to record up to five sets of tests at the site. We recommend that you do the five sets of tests as they will provide a broad picture of the soil conditions at the selected site.

### 6. Review your test procedure.

As you become more familiar with the test procedures and your soils, check whether the sites you have selected are the best sites for the information you need. Also review the way you do your tests to ensure consistency. Make notes as you go to remind yourself next time.

### 7. Review your results and follow up on low scores.

Line up your test sheets for areas you wish to compare and look for similarities and differences among your scores for the 10 tests. Can you explain the differences? If you have neighbours also undertaking tests, get together with them and compare notes.

Where you have low scores in the results, refer to sheet that lists possible causes; obtain and read the literature linked to those tests in order to find out how you might improve your soil health.

Discuss your results with an agricultural adviser or NSW Agriculture extension officer.

### 8. Make sure the test date is on all your soil health cards before you file them.

### 9. Make a note in your diary to repeat the tests after 6 or 12 months.

## 3. Test preparations

### WHEN TO TEST

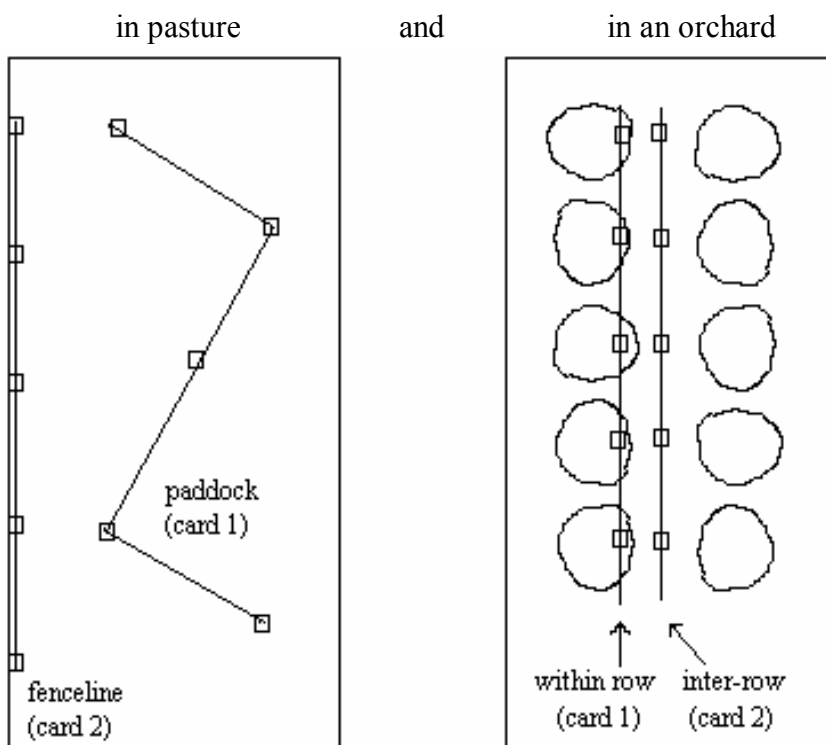
Best results will be obtained in autumn, two to ten days after good rain. To allow comparison of results from year to year, sample at the same time of year and under similar conditions. Avoid taking samples from overly wet soils or during drought, at times of extreme high or low temperatures and within a few weeks of fertiliser or lime applications.

### EQUIPMENT

- home-made wire quadrat (see Sheet 4)
- home-made penetrometer (see Sheet 4)
- home-made infiltrometer tube (see Sheet 4)
- clipboard and pencil
- one soil health card for each set of tests planned
- spade
- heavy duty plastic sheet, 1m x 1m (approx.)
- soil pH kit (available from rural stores)
- small, wide mouthed jar with a lid, marked to show 125 ml level
- 500 ml measure
- container of water (allow 1250 mls water per sample point if soil is dry or 750 ml if soil is moist)
- watch with a second display

### SAMPLING PROCEDURE

Suggested layout of sample points:



#### Notes

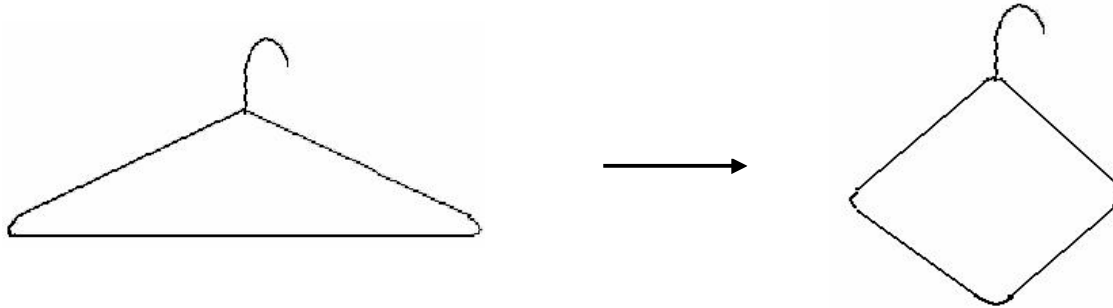
- Start from an identifiable point (eg. paint on fence post).
- Stay within a single soil type for each card.
- Sketch a plan of the sample points on the back of the assessment sheet and mark any soil type boundaries.

## 4. Home-made equipment

### 1. WIRE QUADRANT (Test 1)

A quadrant is simply a frame that shows a known area when placed on the ground. It is used to obtain an accurate measure of anything found there. You will use it to assess the amount of plant cover and then again to record the variety of animal life in the leaf litter.

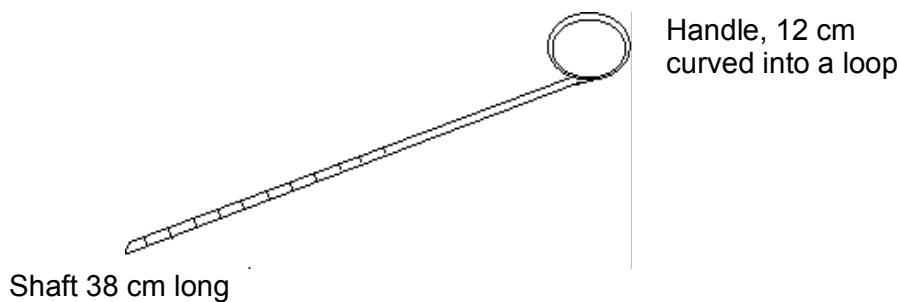
Take a wire coat hanger and open it out to form a square (each side will be approximately 24 cm in length). Leave the hook on so you can hang it in the shed between tests!



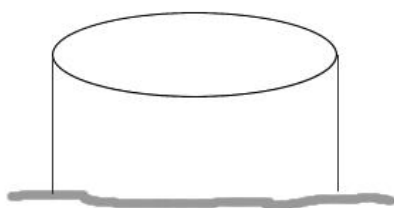
### 2. PENETROMETER (Test 2)

A penetrometer is a device to test the compaction of the soil. While you can buy sophisticated penetrometers for hundreds of dollars, you can make your own inexpensive version. Take a 50 cm length of 3.15mm/10 gauge high tensile wire; use 12 cm of the length to make a handle and on the remaining 25 cm make file marks every 2.5 cm from the end.

Metal rod (50 cm long, 3.15mm diameter) with file marks every 2.5 cm starting from end of rod.



### 3. INFILTROMETER RING (Test 3)



An infiltrometer measures the rate at which a fixed volume of water soaks into the soil.

You will need a 150 mm diameter PVC pipe cut to 11 cm length. Bevel the bottom end to make it easier to push into the soil.

## 5. The soil tests

**WARNING: Soil naturally contains many microbes, some of which can cause infection or disease. Wear gloves if you have injuries or abrasions on your hands.**

### 1. Ground cover

Throw your coat hanger quadrant onto the ground at random and estimate the proportion of bare soil within the frame. Subtract this from 100% to calculate ground cover. Examine surface litter or mulch to estimate its depth. On the test sheet note the grade which best matches your soil. Both ground plants and mulch contribute organic matter to the soil that will feed soil animals and microbes. Roots of ground plants also help maintain good soil structure.

### 2. Penetrometer

Push your homemade penetrometer into the soil as deep as you can with modest effort. Record the depth of penetration on your assessment sheet. If you hit a rock or tree root, choose another spot. The easier it is to penetrate the soil, the better the deep root development and water infiltration.

### 3. Infiltrometer

If the top 7 cm of soil is dry you must perform this test twice in each location and record the time of the second test for an accurate assessment. If the soil is saturated (field capacity) you will need to wait two days for drying before conducting the infiltrometer test.

- Clear the area of residue and trim the vegetation as close to the soil as possible without disturbing the soil.
- Push the infiltrometer ring 2 cm into the soil, avoiding cracks and other holes in the ground. The ring should be nearly level for accurate testing. Use your finger to gently firm the soil around the inside edge of the ring to prevent leakage of water here.
- Carefully pour 500 ml of water into the ring and note the time.
- Stop timing when the surface is just glistening.

A higher rate of infiltration will mean your soil will absorb rainfall more quickly, resulting in less run off and erosion.

### 4. Diversity of soil life

Throw your coat hanger quadrant on the ground in an area not disturbed by earlier tests. Examine the surface for soil animals and then carefully sift through the litter. Note how many different **varieties** of soil animals you see such as ants, beetles, spiders, slaters, millipedes, mites etc. It is the variety that is important, not the numbers - a column of ants counts as one variety.

### 5. Root development

With your spade cut a 20 cm square hole to a depth of 20 cm. Lift the soil out, trying to keep it in one block, and place it on the plastic sheet. Examine the distribution of plant roots and complete the card. The distribution of fine roots will show whether soil structure is restricting the plants' access to nutrients.

### 6. Soil structure

Break a small handful of soil away from near the original surface of the block you have dug up and examine the size and arrangement of the soil aggregates or 'crumbs' (discrete clumps of soil particles). Under firm finger pressure soil should be friable, breaking into crumbs varying in size up to about 10 mm. There should also be evidence of root penetration throughout. Poor structure may be seen either as overly solid soil (hard crumbs, soil layers or clods) or as very loose soil

(absence of even small crumbs, as for example in beach sand). Good structure results in easy passage of air and water, an ability to hold water and superior resistance to erosion.

### **7. Aggregate stability**

Select three or four pea-sized soil aggregates from about 10 cm depth, avoiding small stones. Drop the aggregates into 125 ml water in the small wide mouthed jar and allow to stand for one minute. Observe if the aggregates break apart or stay intact. If they are intact after one minute, gently swirl the bottle several times and observe again. If they are still intact, swirl the bottle vigorously and check again. The aggregates of a healthy soil are normally more stable than those of a less healthy one. Poor aggregate stability is associated with greater susceptibility to erosion. Repeat the test with a sample from a depth of 20 cm.

### **8. Earthworms**

Break up your entire soil block into crumbs and place any worms found into a jar. When done, count any worms that are longer than 25 mm, record on the sheet and return the worms to the hole. Higher numbers of earthworms indicate conditions that are favourable (more organic matter, high pH, low chemical residues). Mostly these are also conditions favourable for plant growth.

### **9. Soil pH**

Take two small samples of soil from the side of the hole, one from 5 cm and one from 20 cm depth. Test each sample for pH, following the instructions included in the kit. Acidity has a strong effect on the ability of plants to take up soil nutrients as well as upon the wellbeing of soil organisms.

### **10. Leaf colour**

Examining your crop, trees or pasture at the soil test site may reveal plant health problems not identified by the completed soil tests. In crops or orchards examine fully formed leaves about four leaves back from the growth tip. (Young leaves at the tip are often naturally pale or red leaves while old leaves nearer the stem may show mottling that is normal).

## **SOME EXTRA (OPTIONAL) TESTS**

### **Calico strip test for soil microbes**

Microbes in the soil (bacteria, protozoans and fungi) play a major role in the break down of soil organic matter. Microbial activity can be estimated by measuring the rate of breakdown ('rotting') of calico. Cut unbleached and washed calico into 20 cm squares. Using a felt tip pen draw a line across the square 5 cm from one edge. Make a cut in the ground to a depth of 15 cm with the spade and, again using the spade, insert the calico so that the marked line coincides with the soil surface. Arrange the top 5 cm of calico vertically in the litter layer, if present. Use at least 5 calico strips at each test site and leave in place for three weeks. Gently retrieve and rinse in a kitchen sieve, to remove attached soil. Place over a piece of graph paper and estimate the percentage area of the calico that has completely decomposed. The more the calico has rotted away the healthier the community of soil organisms.

### **Bioturbation**

Bioturbation is the mixing of surface organic matter into the soil profile by organisms. On the side of the hole dug at Test 5, observe the distribution of the darker soil colouration that is due to organic matter in the profile. Note the depth to which you can detect this darker soil and record on your sheet.

### **Erosion**

Take a 50 cm length of 100 mm x 50 mm timber and place it on the ground, across the slope, near the bottom of a long incline. After each major rainfall event check the wood for a build up of soil on the upper side.

## SOIL HEALTH CARD RESULTS SHEET

Date: \_\_\_\_\_ Location / management: \_\_\_\_\_ (draw a sketch map overleaf)

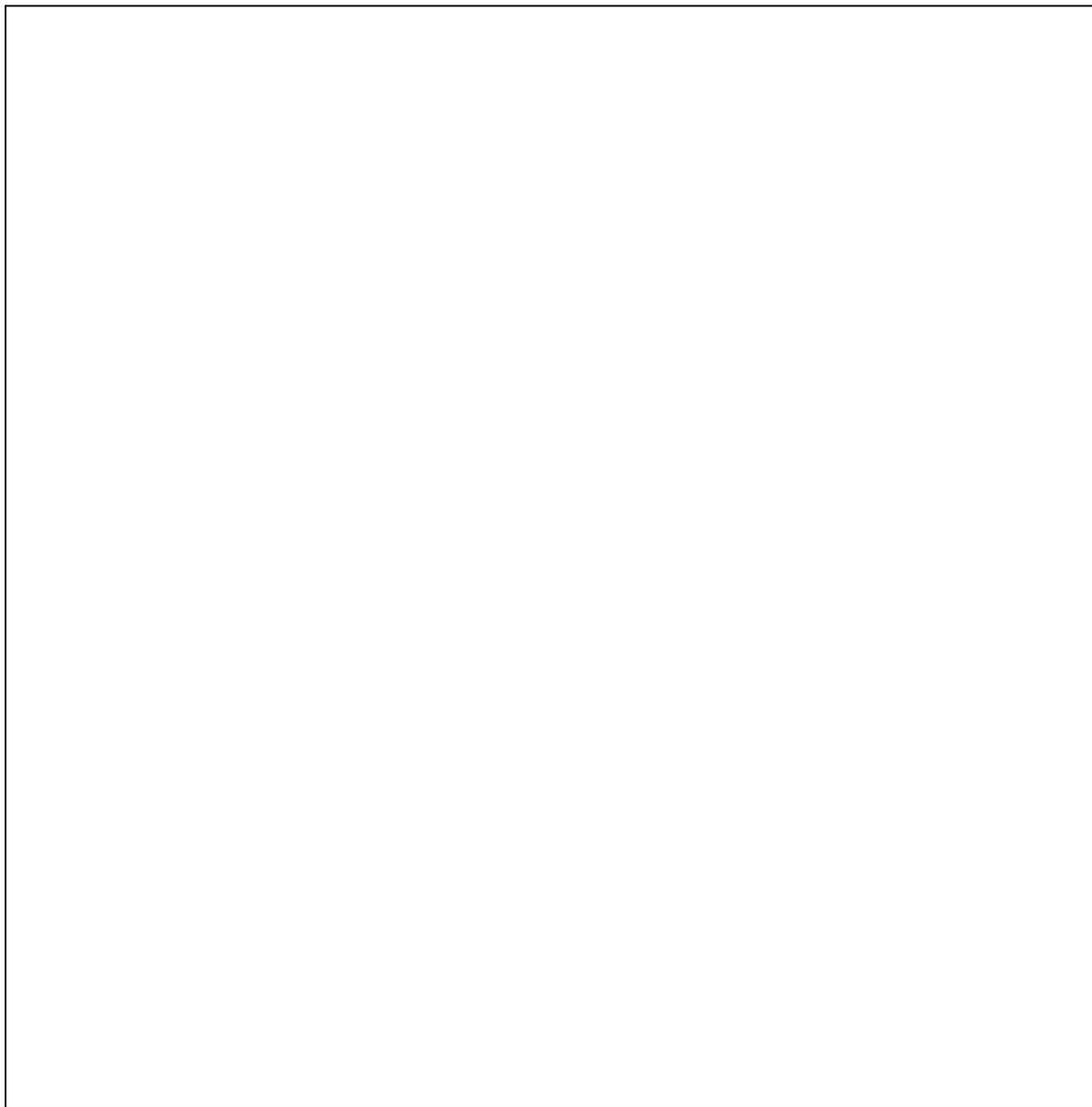
Soil Type: \_\_\_\_\_ Productivity: \_\_\_\_\_ Days since 20mm Rain: \_\_\_\_\_ Soil Moisture: dry / moist / water logged

TEST ▼	RESULT ►	POOR			FAIR			GOOD			TEST SCORES (1 - 9)					
		1 ----- 2 ----- 3	4 ----- 5 ----- 6	7 ----- 8 ----- 9	1	2	3	4	5	Av.						
1. GROUND COVER	Less than 50% ground cover (ground plants or mulch)	50% to 75% ground cover (ground plants or mulch)	More than 75% ground cover (ground plants or mulch)													
2. PENETROMETER	Wire probe will not penetrate.	Wire probe penetrates with difficulty to less than 20 cm.	Wire probe easily penetrates to 20 cm.													
3. INFILTRATION	More than 7 minutes	3 to 7 minutes	Less than 3 minutes													
4. DIVERSITY OF MACROLIFE	Fewer than two types of soil animals.	Two to five types of soil animals.	More than five types of soil animals.													
5. ROOT DEVELOPMENT	Few fine roots only found near the surface.	Some fine roots mostly near the surface.	Many fine roots throughout.													
6. SOIL STRUCTURE	Mostly in clods or with a surface crust, few crumbs.	Some clods but also many 10 mm crumbs.	Friable, readily breaks into 10 mm crumbs.													
7. AGGREGATE STABILITY 10 cm depth → 20 cm depth →	Aggregate broke apart in less than one minute.	Aggregate remained intact after one minute.	Aggregate remained intact after swirling.													
8. EARTHWORMS	0 - 3	4 - 6	more than 6													
9. SOIL pH 5 cm depth → 20 cm depth →	pH 5 or lower	pH 5.5	pH 6 to pH 7													
10. LEAF COLOUR	Stunted plants, leaf discolouration.	Some variation in growth and colour.	Appropriate leaf colour and uniform plant growth.													

NB Numbers resulting from the different tests are not intended to be combined to give an overall value of soil health.

## SITE PLAN

(Showing a permanent reference point, 5 sample points, soil type changes etc)



## NOTES

This document is available at  
[www.tuckombillandcare.org.au](http://www.tuckombillandcare.org.au)  
[www.soilcare.org.au](http://www.soilcare.org.au)

## LOW TEST SCORES: SOME POSSIBLE CAUSES

Further information on many of the possible causes for low soil health scores may be found in the references given overleaf.

Test result	Situation indicated	Possible causes
1) Low ground cover	ground plants absent or growth is poor	unsuitable plant type(s), soil compaction, erosion, shading, trampling (especially when wet), overstocking
2) Low probe penetrability	soil is generally hard hard at the surface only hard layer at greater depth	compacted by traffic, livestock or by over-working. Organic matter content low. compacted by traffic or livestock, especially if soil is wet at the time compacted by heavy vehicles or 'hard pan' formed by soil inverting cultivators
3) Slow water infiltration	high proportion of clay particles lack of spaces, channels or burrows in soil	naturally high clay content of soil type, possible loss of topsoil soil compaction, poor soil structure, lack of earthworms, surface crusting
4) Low variety of soil fauna	lack of habitat or food for fauna poor soil structure presence of harmful chemicals	sparse litter, low soil organic matter, lack of soil spaces and channels frequency or intensity of tillage has been excessive mortality from recent use of insecticides or regular use of cumulative chemical(s) such as copper
5) Poor root development	hard soil lacking spaces poor plant nutrition root disease or attack	loss of topsoil, poor soil structure, soil compaction soil pH not suitable for crop, lack of major or minor nutrients presence of soil-borne pathogen, root-feeding nematodes or root-feeding insects
6) Low earthworm count	pH unfavourable poor food supply lack of soil spaces predators or parasites present presence of harmful chemical	soil pH naturally low, pH reduced by use of acidifying fertilisers sparse litter and/or ground cover (and roots), low organic content, low populations of fungi and bacteria loss of topsoil, soil compaction, poor structure predators (such as flatworms) and parasites (eg parasitic fly) may occur in 'plague' numbers mortality from recent use of insecticides or regular use of cumulative chemical(s) such as copper
7) Poor soil structure	powdery soil, few crumbs excessive clods	lack of soil-binding substances and processes, low soil organic matter (sparse ground cover), few worms topsoil loss, soil compaction, low organic matter, 'puddling' of wet soil by stock, excessive cultivation
8) High slaking	soil particles disperse when wet	10 cm: topsoil loss, compaction, low organic matter, excess tillage 20 cm: poor mixing of soil by soil animals, acid conditions
9) Low pH	high level of acidity	5 cm: excess of nitrogen from inorganic fertilisers and legumes, poor drainage, low organic matter 20 cm: shallow top soil, unused N leached from above, if pH is less than 4 consider acid sulfate soil (grey clay, sometimes with yellow veins)
10) Poor leaf colour	unthrifty plant	soil problem as indicated in tests 1-9, one or more essential nutrients deficient or unavailable (confirm via soil or leaf analysis), low organic matter, disease, waterlogging

**The Northern Rivers Soil Health Card is the result of many months work by northern rivers landholders working in conjunction with NSW Agriculture scientists and TAFE teachers. Tuckombil Landcare Inc. would like to thank the individuals and organisations who, by their concern for soil health, have contributed to this document.**

**Farmer/Industry**

Dave Forrest	Macadamia and Native Foods
Alan Graham	Dairy
Kirk Hickey	Macadamia
Mike Hogan	Avocado
Beth Hotson	Macadamia
Ian Hotson	Macadamia
Gary Lock	Macadamia and Avocado
Peter Morrissey	Coffee
David Roby	Avocado and Vegetable
Elliot Tuckwell	Avocado and Custard Apple
Bonnie Walker	Avocado and Macadamia
David Wilson	Dairy
Jodie Shelley	Avocado, Citrus and Lemon Myrtle
Mal Thompson	Gardening

**NSW Agriculture**

Justine Cox  
Tim Kingston  
Abigail Jenkins  
Rebecca Lines-Kelly  
Greg Reid  
Lukas Van Zwieten

**TAFE Wollongbar**

Alan Coates  
Dave Forrest

The Soil Health Card  
on-line at  
[www.tuckombillandcare.org.au](http://www.tuckombillandcare.org.au)

**Local sources for more information on soil health:**

NSW Department of Agriculture publications available from Wollongbar Agricultural Institute, Bruxner Highway, Wollongbar, NSW.

***Soil Sense – Soil Management for NSW North Coast Farmers*, 2000** Cost \$20.00

This book is for farmers on New South Wales' north coast, a narrow corridor between the Great Dividing Range and the sea, stretching from Tweed Heads to Taree. The closeness of the mountains to the sea gives the region a microclimate unlike anywhere else in New South Wales. *Soil Sense* has been compiled to help you understand your soil so that you can manage it productively. It outlines simple management techniques that you can use, but does not go into explanatory detail. Rather, the book is designed to give you enough information to be able to discuss your soil management options with your local agronomist or horticulturist.

***Soil Health – The foundation of sustainable agriculture*, 2001** Cost \$20.00

This book is the proceedings of a workshop on the importance of soil health in agriculture. The workshop aimed to review NSW Agriculture's soil health research and extension activities, identify general soil health issues, identify issues specific to different farming systems that need further attention and identify strategies to address these issues. The book is divided into sections on soil biology and its importance in healthy soils, soil chemistry and physics and their influence on soil health, and soil health and farm management.

**Soil Management Leaflets and Soil Sense Notes - free of charge**

- Soil management in orchards.
- Soil management for dairy and beef grazing.
- Soil management for bananas.
- Soil management for sugar cane.
- Soil management for commercial small crops.
- What is Soil pH?
- Don't let nitrogen acidify your soil.
- Which liming material is best?
- Why worry about acidity?
- How to interpret your soil test.
- How earthworms help your soil.
- Soil organic matter.
- Protect your soil from compaction.
- How cultivation affects your soil.
- Check your soil structure.
- Cation exchange capacity.

**On-line resources:**

NSW Agriculture [www.dpi.nsw.gov.au/publications](http://www.dpi.nsw.gov.au/publications)

Tuckombil Landcare [www.tuckombillandcare.org.au](http://www.tuckombillandcare.org.au)

SoilCare Inc [www.soilcare.org.au](http://www.soilcare.org.au)

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.

The most reliable sources of information on-line will be found at university and government sponsored web-sites.

**Disclaimers:** The information contained in this publication is based on knowledge and understanding at the time of writing (2002). 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 the information with the appropriate officer of NSW Agriculture or the users independent adviser.