How does my pasture grow

Soil Pit Field Day

28th May 2012

On the property of David Hamilton

“Bolarum”

Strathbogie-Euroa Rd, Strathbogie

Introduction

This soil pit day is part of project, Beyond SoilCare funded through the Caring for Our Country program and supported by the Strathbogie Tablelands Landcare Group, the Goulburn Broken Catchment Management Authority and the Department of Primary Industries.

The theme of the day is "How does your pasture grow". The condition of the soil will be the single most important factor that determines how well pastures can grow in the Strathbogie Tablelands. Normally, when we are looking at soils and thinking about their condition we focus on the top 10 cm., after all that is the zone that we can most directly influence through our short term management .

However the roots of the plant explore the soil profile to much greater depths and the health of the soil down the profile has a major impact on the thrift and long term survival of pastures.

In this field day we will be looking at the soil profile, how it changes in position in the landscape, and the chemical and physical characteristics of the soil that affect plant growth.

There will be the opportunity to get involved on a few simple soil tests that will give you the tools to look at your own soils in greater detail.

At the back of this booklet is an assessment sheet that is a cut down version of one developed by Bass Coast Land care. You can use this as a guide to what you are going to hear about during the day and as an aid when you return home.

Geomorphology of the Strathbogie Tablelands

The Eastern Victorian Uplands is centred on the main divide in eastern Victoria, separating streams draining north to the Murray-Darling Basin from those flowing southwards directly to the sea.

The main streams draining northwards are the Goulburn, Indi, Mitta Mitta, Kiewa, Ovens and King Rivers. The most important streams flowing southwards to the sea are the Latrobe, Thomson, Macalister, Mitchell, Tambo, Nicholson and Snowy Rivers and their tributaries. Apart from the Snowy River, these streams all reach the sea through the Gippsland Lakes of south-eastern Victoria. Further east, the Bemm, Cann and Genoa Rivers flow directly into Bass Strait to drain the eastern part of the Eastern Uplands. The Yarra River, the main river draining the south-western part of the region, flows into Port Philip Bay.

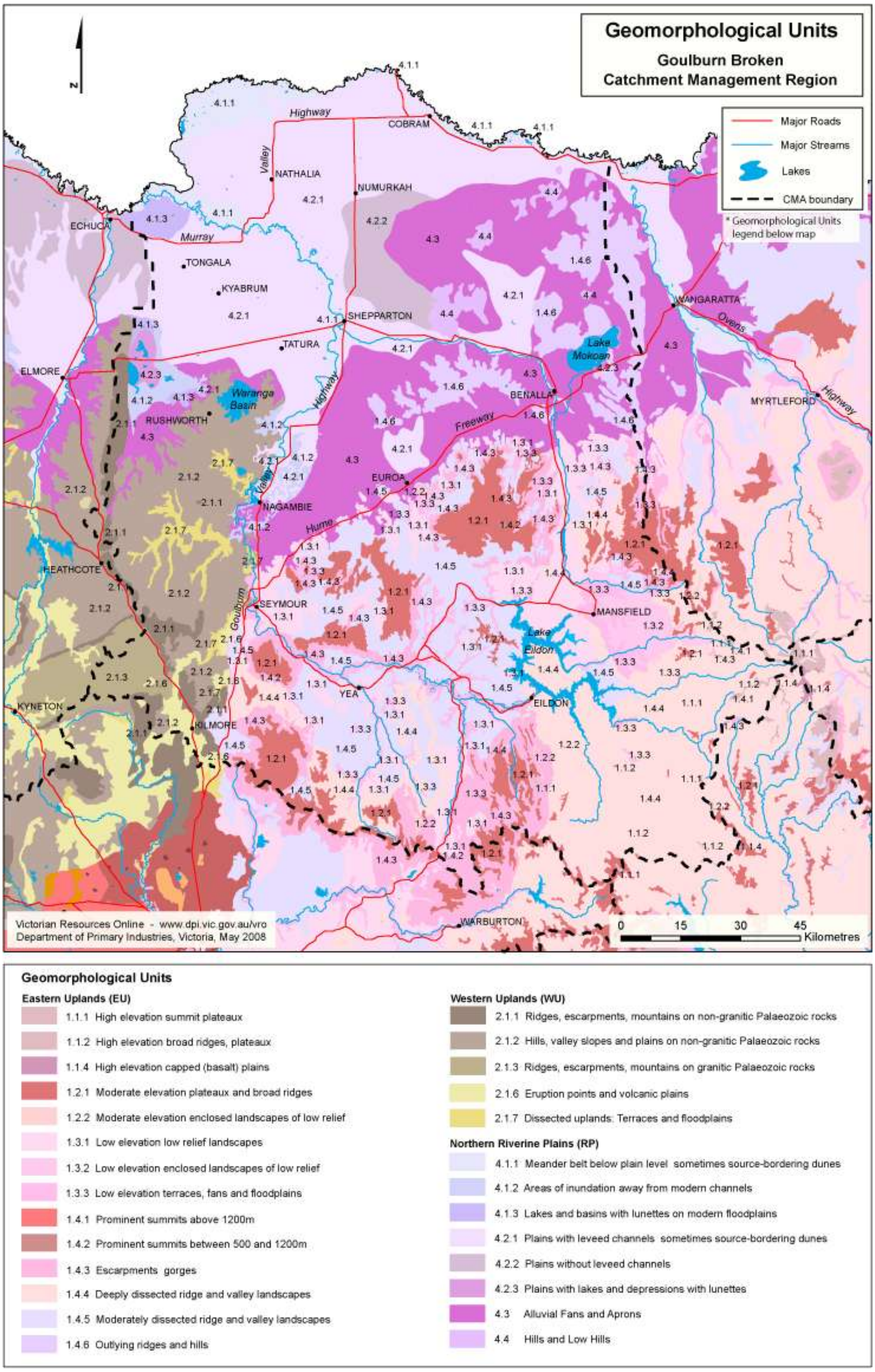
Extensive landscapes of low relief (plateaus) occur at high elevations e.g. Bogong High Plains (about 1 500 – 1 600 m), the plateaus of Mt. Buffalo (about 1 400m) and Mt Baw Baw (about 1 567 m). These are commonly referred to as “high plains”. There are also extensive plateaus at successively lower elevations the further they are from the main divide, e.g. the Pinnibar plateau in the north-east and the Nunniong plains to the south (about 1 200 m), the Koetong - Shelly, Wabonga and Strathbogie plateaus further north (about 600 - 1 100 m), and the Kinglake surface in the south west of the region at about 275 m

The northerly draining valleys widen and the stream gradients gradually decrease as they near the Riverine Plain to the north and west of this region. The lower reaches of these streams have flood plains of fine sediments flanked by several sets of terraces. A landscape formed by the top terrace may be equivalent to the Nillumbik Terrain found south of the Great Divide. Alluvial or colluvial cones emerge from minor valleys of small ephemeral streams that drain the major valleys. As the ridges approach the lowland plains, low hills mark the later stages of erosion of the upland ridges, e.g. the Lurg Hills near Benalla and the hills around Rutherglen

The geology of much of the region is intensely folded Lower Palaeozoic sedimentary rocks or regionally metamorphosed derivatives (gneiss and schist). Granite intrusions have formed Mt. Buffalo and the Baw Baw Plateau, and underlay the Koetong-Shelly plateau and the Strathbogie tablelands.

Flat-lying basalt from the Palaeogene (*Older Volcanics*) occurs as residuals in elevated areas of low relief, e.g. on the Bogong High Plains, the Dargo High Plains, the Nunniong Plateau and Mt Useful.

The Eastern Uplands meet the Western Uplands at the Kilmore Gap just north of Melbourne at an elevation of only 350 m.


Geomorphological Units
Goulburn Broken
Catchment Management Region
Major Roads
Major Streams
Lakes
CMA boundary
* Geomorphological Units legend below map
COBRAM
NATHALIA
NUMURKAH
ECHUCA
TONGALA
KYABRUM
SHEPPARTON
TATURA
WANGARATTA
ELMORE
RUSHWORTH
BENALLA
MYRTLEFORD
EUROA
NAGAMBIE
HEATHCOTE
SEYMOUR
MANSFIELD
YEA
EILDON
KYNETON
KILMORE
WARBURTON
Murray
Highway
Valley
Hume
Freeway
Goulburn
Ovens
Waranga Basin
Lake Mokoan
Lake Eildon
Victorian Resources Online - www.dpi.vic.gov.au/vro
Department of Primary Industries, Victoria, May 2008
0 15 30 45 Kilometres
Geomorphological Units
Eastern Uplands (EU)
1.1.1 High elevation summit plateaux
1.1.2 High elevation broad ridges, plateaux
1.1.4 High elevation capped (basalt) plains
1.2.1 Moderate elevation plateaux and broad ridges
1.2.2 Moderate elevation enclosed landscapes of low relief
1.3.1 Low elevation low relief landscapes
1.3.2 Low elevation enclosed landscapes of low relief
1.3.3 Low elevation terraces, fans and floodplains
1.4.1 Prominent summits above 1200m
1.4.2 Prominent summits between 500 and 1200m
1.4.3 Escarpments gorges
1.4.4 Deeply dissected ridge and valley landscapes
1.4.5 Moderately dissected ridge and valley landscapes
1.4.6 Outlying ridges and hills
Western Uplands (WU)
2.1.1 Ridges, escarpments, mountains on non-granitic Palaeozoic rocks
2.1.2 Hills, valley slopes and plains on non-granitic Palaeozoic rocks
2.1.3 Ridges, escarpments, mountains on granitic Palaeozoic rocks
2.1.6 Eruption points and volcanic plains
2.1.7 Dissected uplands: Terraces and floodplains
Northern Riverine Plains (RP)
4.1.1 Meander belt below plain level sometimes source-bordering dunes
4.1.2 Areas of inundation away from modern channels
4.1.3 Lakes and basins with lunettes on modern floodplains
4.2.1 Plains with leveed channels sometimes source-bordering dunes
4.2.2 Plains without leveed channels
4.2.3 Plains with lakes and depressions with lunettes
4.3 Alluvial Fans and Aprons
4.4 Hills and Low Hills

Soil Profile

Soil profile is a side view or vertical cross-section of the soil as seen in a ditch, road cutting, bank or soil pit. The soil profile is divided into layers or "horizons." These layers differ in colour, physical properties, chemical composition, and biological characteristics. A soil profile has three major parts or horizons: (1) the topsoil or "A" horizon, (2) the subsoil or "B" horizon, (3) the parent material or "C" horizon. A hypothetical soil profile is shown in Figure 1.

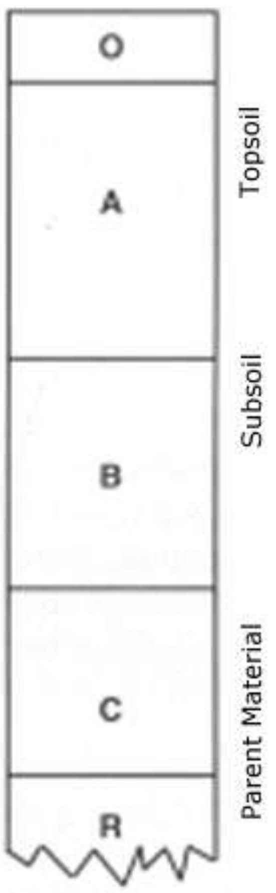


Figure 1 Hypothetical soil profile showing the letter designation used in describing the major kinds of horizons usually present

Organic horizon(O) of undecomposed and decomposed organic matter. Absent in cultivated and many other soils.

Mineral surface soil which has accumulated decomposed organic matter and is usually darker coloured than lower layers. It is also the horizon that has lost organic matter, clay, iron, and aluminium due to downward movement.

Mineral horizon that usually has a finer texture, or a darker, stronger, redder colour and a distinctly different developed structure. Structure is often more distinct than in the "A" horizon.

Mineral horizon of weathered parent material like the material from which the soil developed or other substratum of unconsolidated material not related to the above soil.

Underlying consolidated bedrock. Absent under many soils.

Soil Depth

Depth refers to the total thickness of the surface and subsoil plus any underlying material that is favourable for root development. Soils are categorized into several different soil depths. Depth is an important factor of soils. It determines the total amount of water held in the soil, the volume of soil available for plant root growth, and the supply of nutrients available to plants. Generally this material is underlain by bedrock, clay, or shale beds, or alluvial material.

Deep soils have over 100 cm of soil that can be penetrated by plant roots.

Moderately deep soils have between 30 cm and 100 cm of soil that can be penetrated by plant roots.

Shallow soils have between 15 cm and 30 cm of soil that can be penetrated by plant roots.

Very shallow soils have less than 15 cm of soil that can be penetrated by plant roots.

Elements of the soil

Soil texture is the proportion of sand, silt and clay in the soil. Soil texture normally refers to the solid particles less than 2mm in diameter known as the Earth Fraction.

On an average soil, as shown in the pie chart, the mineral particles only comprise about 45% of a soil's volume. Air and water provide about 25% each and the active, live parts of the soil (plant roots, organic matter etc.) usually comprise less than 5% of the volume.

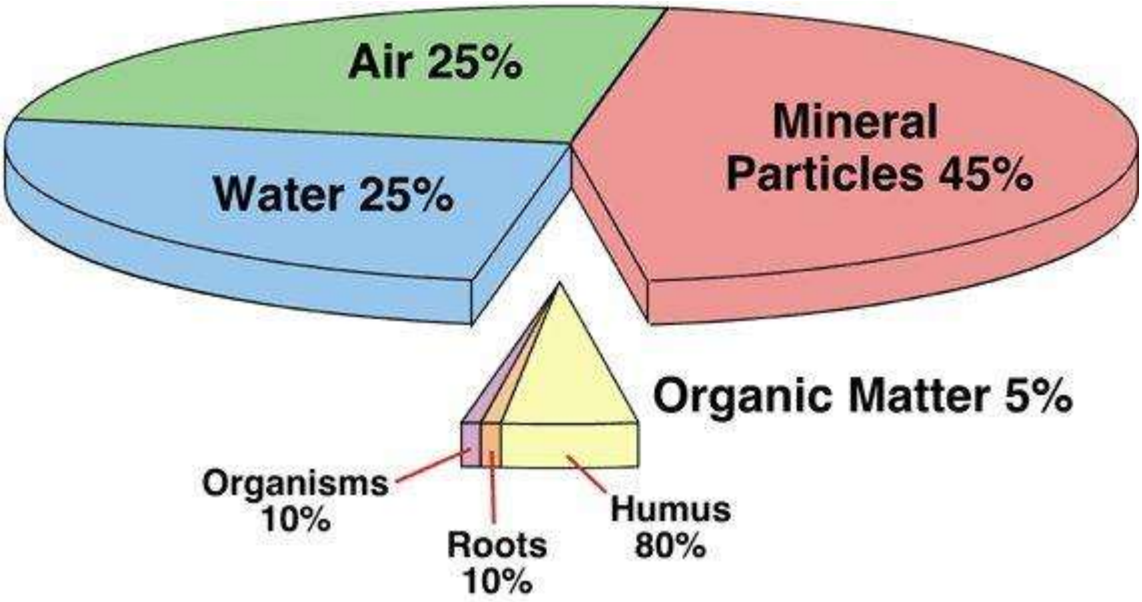


Figure 2 Components of the soil

The soil particles of sand, silt and clay have different characteristics influenced by their particle size and chemistry.

The four standard soil particle sizes are:

- Coarse sand 0.2 – 2mm
- Fine sand 0.02 -0.2mm
- Silt 0.002 – 0.02mm
- Clay < 0.002mm

Sand

Sands are generally sharp angular fragments of weathered rock and mainly consist of the mineral quartz with smaller amounts of other minerals. The particle size of sands is 0.02mm to 2 mm.

Properties of Sand -

- Has large pore spaces between particles.
- Has low water holding capacity.
- Has a low ability to absorb and hold plant nutrients.
- Provides good soil aeration.

Silt

Silt is a smooth soil particle formed from weathered rock and mainly consists of the mineral quartz, with smaller amounts of other minerals. Particle size is 0.02mm to 0.002mm.

Properties of Silt -

- Has higher moisture retention, slower drainage and less aeration than sand.
- Feels smooth and soapy.
- Silt particles provide little in the form of nutrient supply or storage, unless it is coated with clay material.

Clay

Clays are formed by the chemical weathering of rock minerals. Particle size is less than 0.002mm.

Properties of Clay -

- Absorbs and holds plant nutrients.
- Contains very small pore spaces (but has large total pore space).
- Has high water holding capacity.
- Has a very large surface area.

Soil Organic Matter

The term "organic matter" refers to all the plant or animal material in a soil.

The benefits from organic matter come from the release of plant nutrients from decaying material and the formation of "humus". Humus increases the soils ability to store water and retain plant available nutrients.

Various organic and inorganic acids are formed in soils when organic matter decays. These acids help to dissolve soil minerals.

Organic matter is a source of food and energy for many of the soil organisms – including earthworms and useful soil bacteria.

Humus

Humus is the very stable form of organic matter (between 1 and 10% of total soil organic matter). Humus increases the cation-exchange capacity – higher than in mineral colloids (e.g. clay). These colloidal particles have a strong ability to hold on to plant nutrients and so reduce the rate of loss by leaching.

Properties of Humus -

- Has a negative surface charge that helps retain nutrients and water.
- Does not exchange ions as easily as clay.
- Important for building and maintaining soil structure, aiding infiltration and lessening runoff.

Soil Texture

Soil texture refers to the relative proportion of sand, silt, and clay particles in a specific soil mass. It is easiest to determine when the soil is moist. Sand feels gritty when rubbed by the finger. Silt feels slick or velvety. Clay is usually sticky and plastic when wet and when pinched between the thumb and finger forms a flexible ribbon.

How to define soil texture

Soil texture is worked out in the field by manipulating a moistened soil sample between the thumb and fingers.

Take a sample of the soil, moisten it slightly from a water bottle, and work it into a ball between your thumb and fingers. Clay soils can take several minutes. Silty soils can be worked up very quickly, sands don't work up.

The first picture is of a silty clay soil. The soil took a long time to work up so it could be easily moulded. It contained approximately 40-45% clay.



- Clay soils cannot be easily "flicked" from your thumb. Silty soils can be "flicked" off easily.
- Clay soils form large peaks between your finger and thumb. Silty soils do not form peaks of any significance.
- Clay soils leave their yellow colour on your finger. Silty soils can be cleaned right off.
- Silty soils feel "soapy". Clay soils feel "buttery".
- Silty and sandy soils spread out across your hand when shaken. Clay soils stay intact. This is due to both particle shape and particle chemistry.

Soil texture can also be more accurately determined in the laboratory using a variety of mechanical sifting and other technical processes.

There are a number of standard diagrams, usually triangles or pyramids, that explain the standardised naming of soil texture according to the proportions or percentages of sand, silt and clay in the mix.

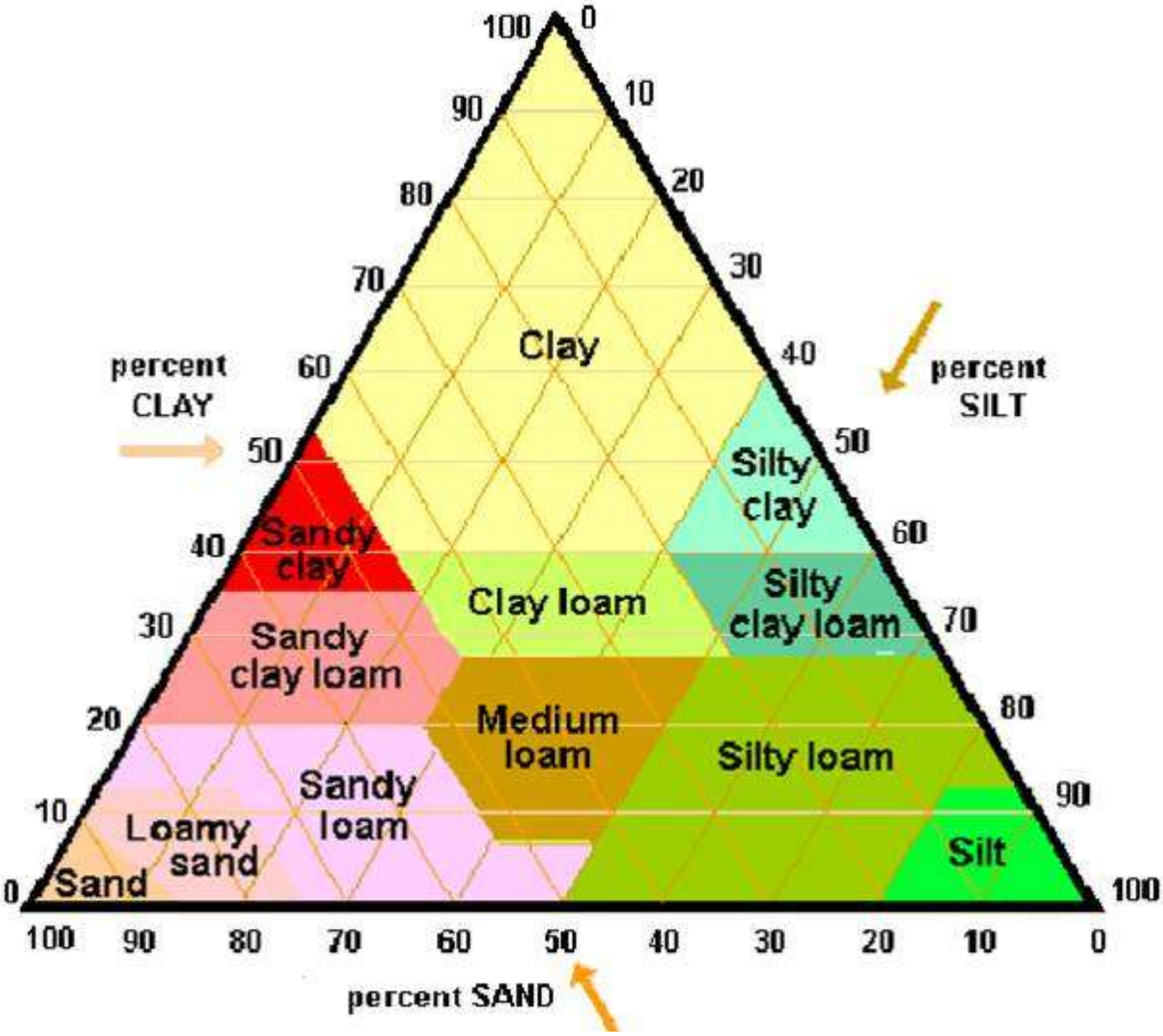
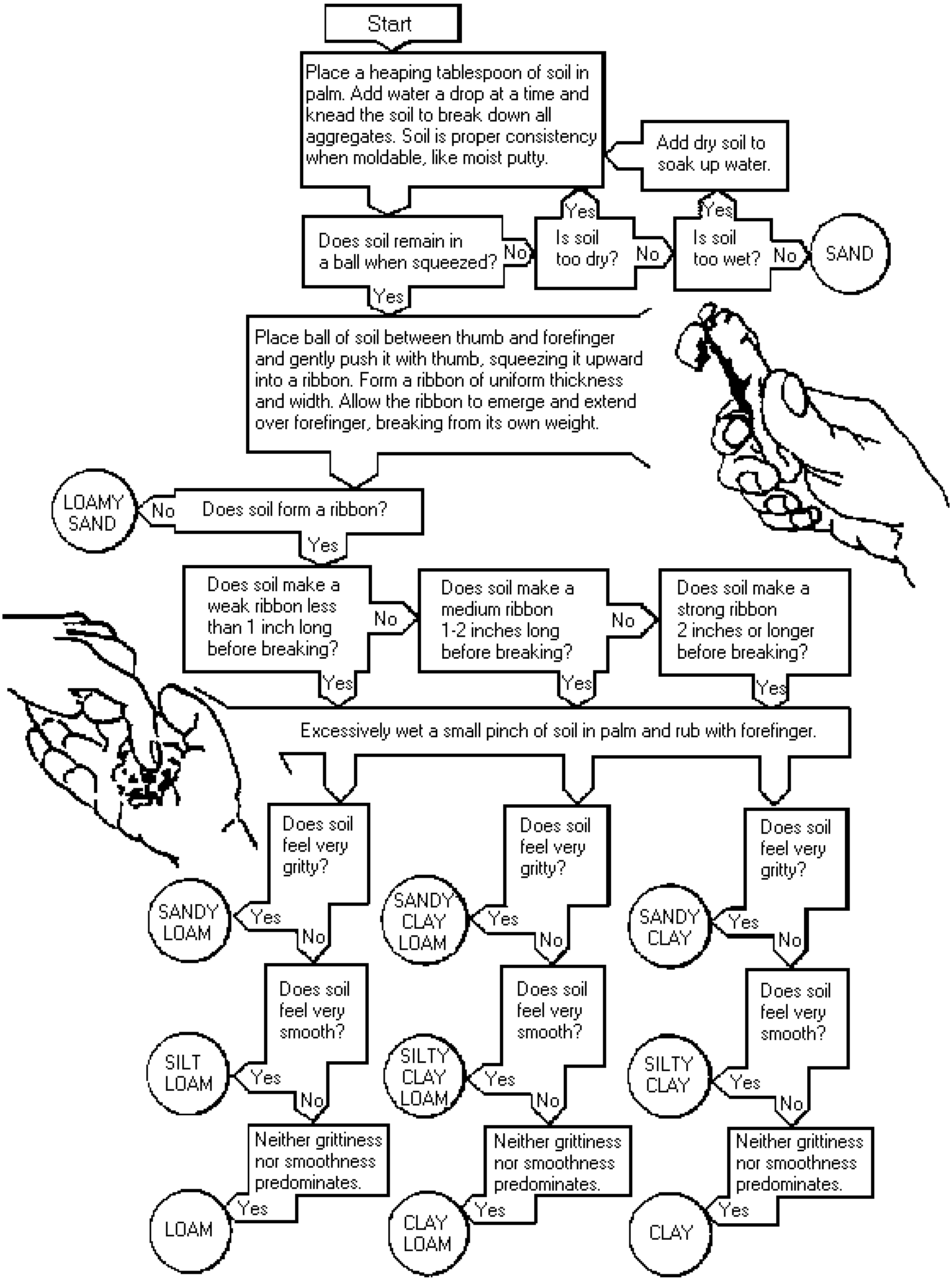


Figure 3 Soil texture triangle Source: http://www.oneplan.org/Water/soil-triangle.asp



Source: http://ag.arizona.edu/oals/watershed/beaver/soiltexture.html. Originally published in Thien, Steve, "A flow diagram for teaching texture-by-feel analysis," *Journal of Agronomic Education*, 1979, vol. 8, pp. 54-55.

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Soil Structure

What is soil structure?

Soil structure is the arrangement of pores and fissures (porosity) within a matrix of solid materials (soil particles and organic matter). The solid materials bond and aggregate to give the pores and fissures. The quantity, distribution and arrangement of pores determines water holding capacity, infiltration, permeability, root penetration, and, respiration.

Soil structure close-up

Only about 50% of soil is solid material. The remainder is pore space. It is in these spaces that the action happens. Water is stored there. Organisms live there. Organic matter and nutrients accumulate there.

The diagram (magnified about 20 times) demonstrates how solids and pores might arrange in soil to give a porosity of 50 %.

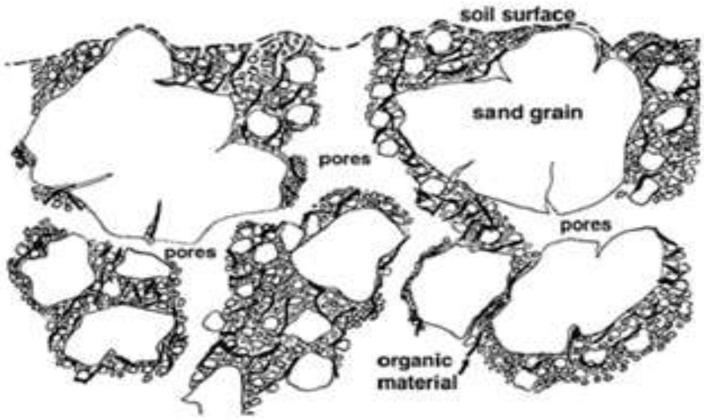


Figure 4. General diagram of soil structure.

Small pores within the aggregates provide storage and refuge. The larger pores (and fissures) between the aggregates are the pathways for liquids, gases, roots and organisms.

Why is soil structure so important?

The structure and layout of soils determine how things happen, the rate at which they happen, and the capability to keep them happening.
The following characteristics are used to help evaluate the ability of any soil to perform well (or otherwise):

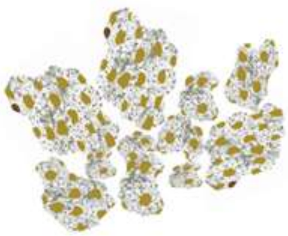
- Porosity (to represent aeration, water storage capacity, plant wilting point and drainage)
- Permeability (to represent infiltration, drainage and respiration)
- Bonding and aggregation (to represent how the solids group together and the construction materials used)
- Soil strength (to represent toughness and resilience of structures)
- Friability, tillage and trafficability (to represent how soils behave with mechanical disturbance)

What types of soil structure are there?

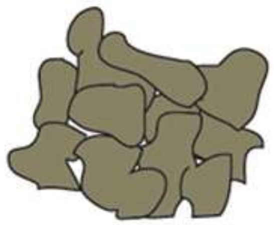
Soil material fits and binds together in many different ways. With some, the bonding is very weak, in others very strong. With some, the size of aggregates is very fine, in others coarse and large. With some the aggregates are dense containing few pores, in others quite open with plenty of pores.

There are six broad categories of soil structure:

Granular (high permeability)

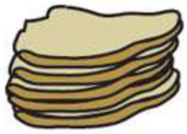


Aggregated (high permeability)

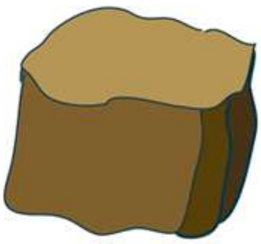


Blocky (moderate permeability)

Columnar/prismatic (moderate permeability)



Platey (low permeability)



Massive (low permeability)

Figure 5 Main types of soil structure

Indicators of damaged soil structure

- Root restriction
- Compacted layers
- Plough pans
- Surface crusting
- Soil erosion

Soil structure stability

Source: Goulburn Broken Catchment Soil Health Kit Procedures Booklet

Soil structure stability is the stability of the pores and aggregates in the soil. The stability of a soil is dependent on the Exchangeable Sodium Percentage (ESP%), ratio of Ca/Mg, organic matter content and soil biological activity. Instability will promote compaction, hard setting, erosion issues and reduce productivity. Soil structure can be improved by minimising disturbance, increasing organic matter, avoiding heavy traffic and gypsum may be added to sodic soils.

Place a few peds into a dish of rainwater or distilled water. Observe what happens immediately, and after 10 minutes, then leave undisturbed for two hours (placing a ped in water simulates what would happen to a paddock with no cover in rainfall). Carry out this test for both the topsoil (0 -10cm) and subsoil (20-30cm).

We are looking for –

Slaking – ped collapses but water is clear

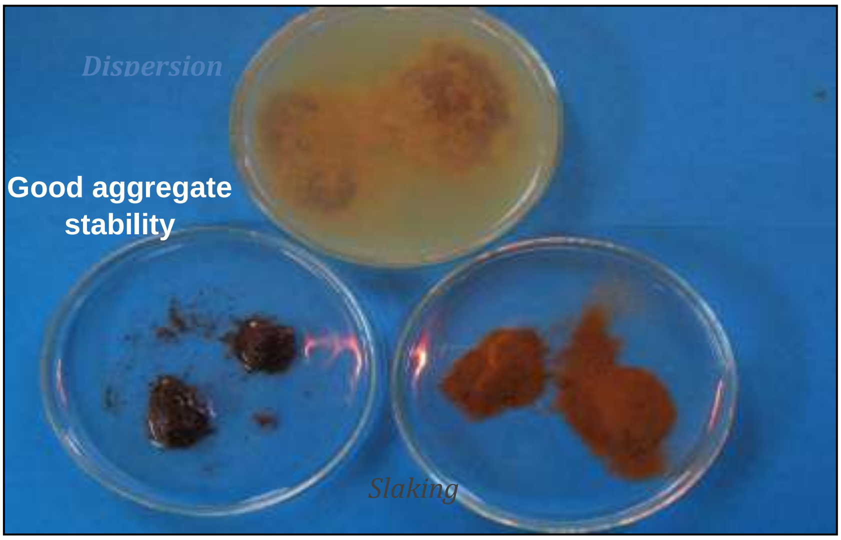
Dispersion – ped collapses and water is cloudy around the ped

If the water around the aggregates becomes cloudy it means the clay in the aggregate has separated into individual particles and **dispersion** has occurred. This indicates that your soil maybe sodic (high in sodium) note that this is different from a soil that is saline.

If the aggregates crumble into smaller fragments in the first 10 minutes, there is not enough organic matter to hold them together, and the soil is said to have **slaked.**

If the aggregates remain intact, there is enough organic matter to keep them together, so conditions are good for plant growth. The pores will remain open after wetting and water will drain quickly. Roots will penetrate easily and there will be no hard crust on drying.

There is one other thing to test for – mould the soil in your hand and place a small pea sized piece of this re-worked soil into the dish and observe what happens. If no slaking occurs now, your soil has excellent soil structural stability. If slaking does occur, you need to be careful about the moisture content of your soils when cultivating. This is to simulate what happens when you work a wet soil after rainfall as some soils may not slake or disperse until worked under wet conditions.



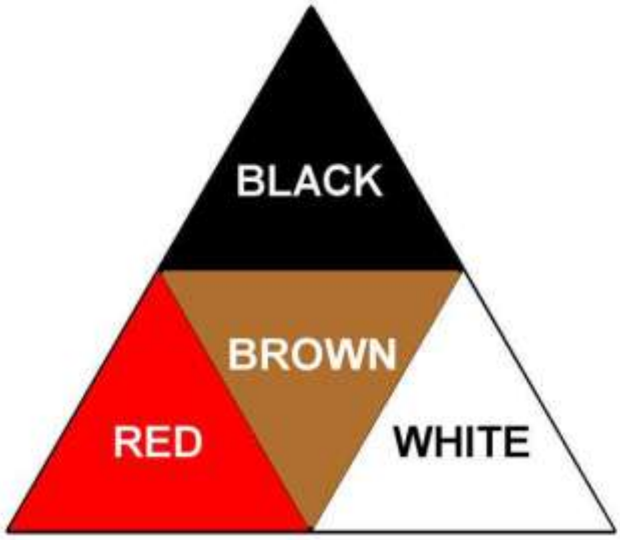


Figure 6 The four influential colours of soil colour

Soil Colour

Colour is one of the most obvious characteristics of soil. Colour can also provide a valuable insight into the soil environment.

The most influential colours in a well-drained soil are white, red, brown and black. White indicates the predominance of silica (quartz), or the presence of salts; red indicates the accumulation of iron oxide; and brown and black indicate the level and type of organic matter. A colour triangle can be used to show the names and relationships between the four influential colours (Figure 6).

What determines soil colour

Four main factors influence the colour of a soil:

Mineral matter – rocks are broken down to form soils, and sometimes these rocks give their colour to the soil. More usually the colour of the soil results from compounds such as iron.

Organic matter – humus, the final stage of organic matter breakdown is black. Throughout the stages of organic matter breakdown the colour imparted to the soil varies from browns to black.

Sodium content influences the depth of colour of organic matter and therefore the soil. Sodium causes the organic matter (humus) to disperse more readily and spread over the soil particles, making the soil look darker (blacker).

Iron – Red, yellow, grey and bluish-grey colours result from iron in various forms. Under average conditions of air and moisture, iron forms a yellow oxide imparting a yellow colour to the soil.

Figure 7 Photographs of mottled soil, indicative of waterlogged conditions

Where soils are well draining or under dry conditions, iron forms red oxides imparting a red colour to the soil. Yet in waterlogged soil, with a lack of air, iron forms in a reduced state giving the soil grey/green/bluish-grey colours.

Water – Soil colour darkens as the soil changes from dry to moist. But longer term colour changes are linked to water relations as well. Careful observation of colour can help to identify problems of waterlogging or leaching.

Poorly drained soils are often dominated by blue grey colours often with yellow mottling. Well drained soils will usually have bright and uniform colours.

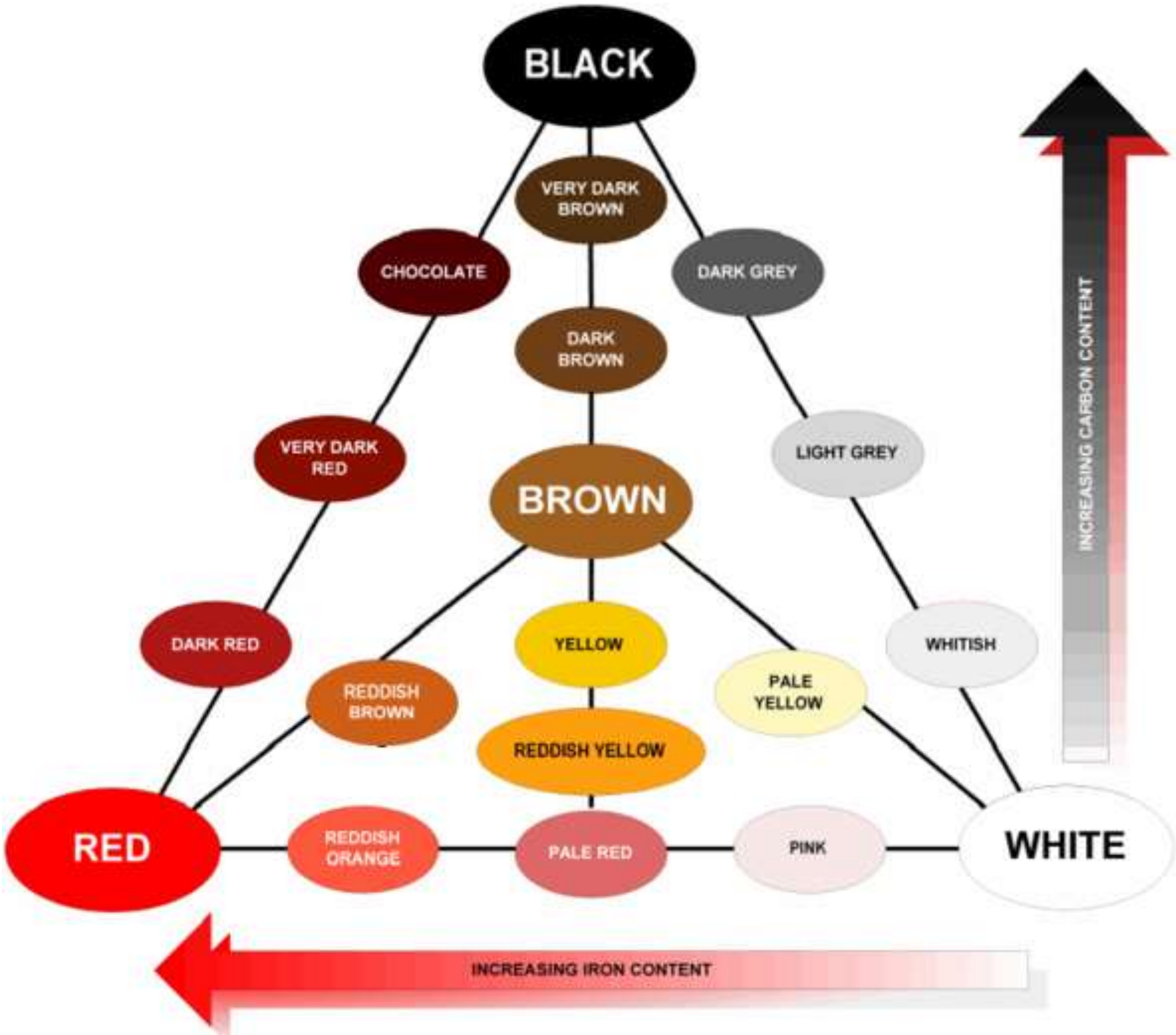


Figure 8 Colour triangle showing relationships between soil colours and influencing factors/conditions

Sources:

PRACTICAL NOTE: Soil Colour An output of the 'Soil Health for Sustainable and Productive Landscapes' Project http://soilhealthknowledge.com.au/images/PDFfiles/pracnote_colour.pdf

The Why and How of Defining your soil's texture http://informedfarmers.com/defining-your-soils-texture/

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What is soil pH?

Soil acidification is a natural process and is generally accelerated by agriculture. The rate of acidification varies enormously depending on the soil type, land use, productivity and management of the farming system.

Acidity is a problem throughout the soil profile. It is common to separate acidification of the topsoil (0 to 10 cm), from that of the underlying soil. In some cases the subsurface soil is acidifying while the topsoil pH has increased since clearing

The pH of soil indicates the strength of acidity or alkalinity in the soil. Soil is neutral when pH is 7, it is acid when pH is less than 7 and alkaline when it is greater than 7. A difference of a unit is a tenfold difference in acidity or alkalinity (e.g. pH 5 is ten times more acid than pH 6).

Carbon cycle

The role of the carbon cycle in soil acidification is connected with product removal and increasing concentrations of organic anions in the soil.

Product removal. When plants absorb nutrients they tend to actively absorb more positively charged nutrients (e.g. NH_4^+, K^+, Ca^{2+}, Mg^{2+}, Na^+) than negatively charged nutrients (e.g. PO_4^{3-}, NO_3^-, Cl^-, SO_4^{2-}) from the soil solution. This excess of cations (positively charged) over anions (negatively charged) is usually balanced by the plant excreting hydrogen ions (H_+) from the roots. The plant tissue becomes alkaline, while the soil is acidified in the region of the roots. If plant tissue is not removed from the area the net effect is zero, although there can be a redistribution of H^+ within the soil profile. However, removal of grain, hay, silage, meat or wool leaves a net excess of H^+ in the soil, causing acidification.

Stock tend to redistribute alkalinity within paddocks when large quantities of dung and urine are deposited in camps. These factors contribute to the spatial variability of soil acidity within and between paddocks.

Nitrogen cycle

The nitrogen (N) cycle is frequently implicated in acidification, but overall it is chemically neutral. The N cycle results in no net change in acidity, *providing the cycle is completed*. If nitrogen enters the soil in one form and leaves in another, there can be a net addition or removal of H^+. In broadscale agriculture, most N enters the nutrient pool through the fixation of atmospheric N by legumes. If the highly soluble nitrate ion is leached below the root neutrality it usually does so in combination with Na^+, K^+, or even Ca^{2+}, leaving H^+ in the leached zone.

Fertilisers

The main fertilisers that contribute to acidification are the nitrogenous fertilisers plus elemental sulphur (S). Elemental S has to be converted to sulphate ions by microbes before plants can absorb it, and this conversion releases H^+. The sulphate ions are soluble and thus readily leached. When sulphate ions leach, they usually do so in association with cations other than hydrogen, thereby acidifying the soil in the leached zone. The contribution of the S cycle to acidification is likely to be small in comparison with the N and C cycle.

Similarly, urea fertilisers cause net additions of H^+ if nitrate is leached. Adding fertilisers that contain N in the form of ammonium (e.g. DAP, MAP) is acidifying even when nitrate is not leached. The role of ammonium-forming fertilisers in lowering pH has been well established.

Adding single, double or triple superphosphate fertilisers does not contribute directly to soil acidity. These fertilisers only contribute by increasing the productivity of the farming system, so they increase the amount of N that can leach or the amount of product that can be removed.

Effects of soil acidity

Nutrient availability. The supply of most nutrients is altered by soil pH (Figure 9). Decreases in the availability of molybdenum and to a lesser extent N, S, P, Ca and Mg can occur in acid soils, although this varies between soils. Increases in availability of Mn, Fe, Al and Zn can also occur. Molybdenum (Mo) supply is reduced when pH_{Ca} is lower than 4.2. The rates of both nitrification ($NH_4^+ \rightarrow NO_3^-$) and nitrogen mineralisation (organic-N$\rightarrow NH_4^+$) are lower in acid soils because soil flora (fungi, bacteria, viruses) generally do not grow rapidly under these conditions. The reduced mineralisation can reduce availability of N, S and P to plants. Conversely, liming raises the pH, causing a large increase in microbial activity, increasing mineralisation of organic matter which releases N, P and other nutrient elements.

Aluminium toxicity. Aluminium (Al) toxicity can be a major problem of acid soils. It can reduce root growth in both the topsoil and subsurface soil. The effect of Al toxicity in the subsurface soil will often be seen as symptoms of drought stress, resulting from the reduced root elongation and branching. Aluminium toxicity is often described as a chemical hardpan, because the effects on root elongation are similar to those caused by subsurface compaction.
The critical soil pH at which sufficient Al becomes soluble to be toxic is difficult to predict because it depends on many factors including clay mineralogy, organic matter, other cations and anions and total salts. In general, Al starts to dissolve when the pH CaCl is lower than 5.5, while below 4.5 there is a marked increase in extractable Al.

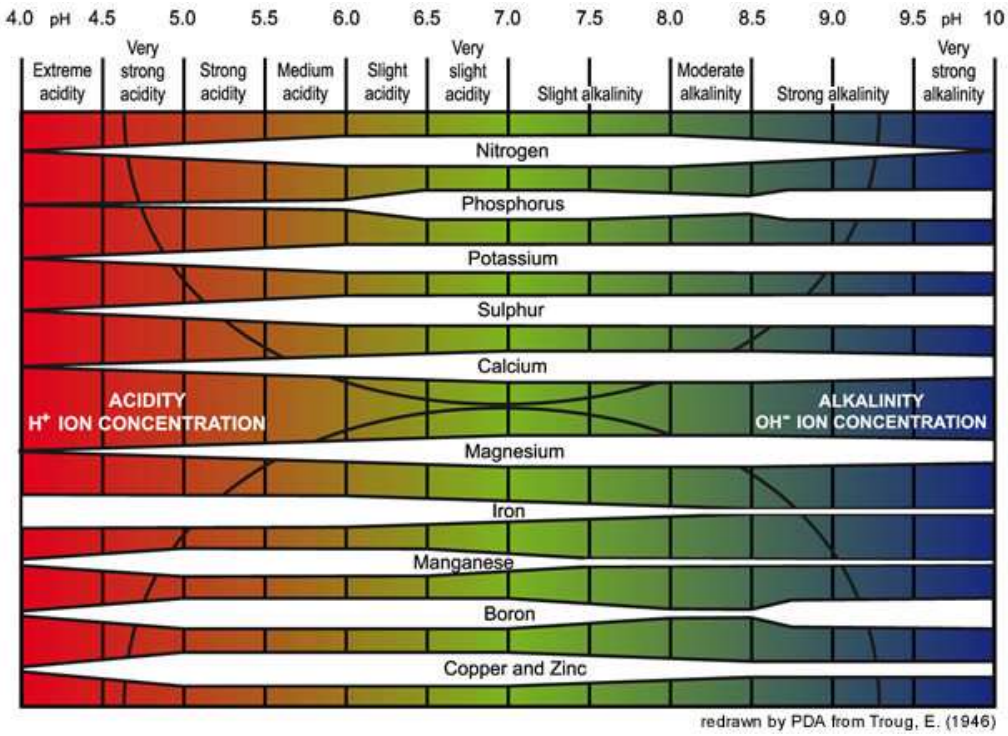


Figure 9 Effect of soil pH on availability of macro and micro nutrients

pH buffer capacity

This is the ability of the soil to resist changes in pH from the acidifying process or the application of lime. This helps explain why some soils acidify more readily than others or respond to lime more quickly.

The buffer capacity varies with pH. Under alkaline conditions (pH_{Ca} >7.5), the buffer capacity is high because of reactions involving carbonate minerals. Similarly, at low pH (pH_{Ca} <4.5), soils may be strongly buffered by reactions involving aluminium hydrous oxides. Between pH_{Ca} 4.5 to 7.5 the soil is less strongly buffered. Factors that increase the buffering capacity include increasing the organic matter, clay and carbonate minerals.

Measuring soil pH

Portable kits have been widely used to provide an indication of soil pH in the field. A small sample is collected and an indicator solution is added to form a paste. The paste is then coated with barium sulphate powder, which changes colour according to the pH of the soil. The colour of the soil-indicator powder is then compared with a colour chart. This method is not as precise as the laboratory methods.

Ameliorating soil acidity

Lime is usually used to increase soil pH in strongly acid soils. The quantity of lime needed will vary between soils. Generally, coarse textured soils (e.g. sands) need less lime than finer textured soils. A lime requirement test will incorporate these affects when used to determine the amount of lime needed to raise soil pH. Other factors needed to determine an appropriate lime rate include target pH of the specific plant, lime quality, application method and economics.

Soils of the Strathbogie region

Chromosols

http://vro.dpi.vic.gov.au/dpi/vro/gbbregn.nsf/pages/soil_soil_gbb_chromosols

Red Chromosol on Hills near Dookie.

Chromosols are soils that display a strong texture contrast between surface (A) horizons and subsoil (B) horizons. The upper part of the subsoil ranges from slightly acid to alkaline (pH >5.5) but is not sodic. Using the Australian Soil Classification, Chromosols can be grouped further (in to Suborders) based on the colour of the upper 20 cm of the subsoil (i.e. Red, Brown, Yellow, Grey and Black). These can be further differentiated based on subsoil characteristics (in to Great Groups) such as the nutrient level capacities and ratios and the presence of carbonate or lime.

Chromosols occur throughout the region and can be found on the alluvial Riverine Plains and the uplands where the dominant occurrences are north, east and west (sporadic occurrences) of Benalla, east of Seymour and the Mansfield area. Surface soil textures and depth vary considerably and have significant implications for management; affecting soil workability, permeability, crop establishment, moisture availability and erodibility. The subsoils of the Brown, Yellow and Grey variants are often mottled. However, this is not the case for some Brown Chromosols on alluvial flats which are friable, where drainage is not restricted.

The Red Chromosols are the most permeable of the Chromosols in the region and tend to be in the slightly higher and thus better drained topographic positions, compared to their Brown, Yellow and Grey counterparts. Although in the case of the Mansfield area, subsoil colour is derived from the lithology (i.e. Carboniferous red beds).

Red Chromosols

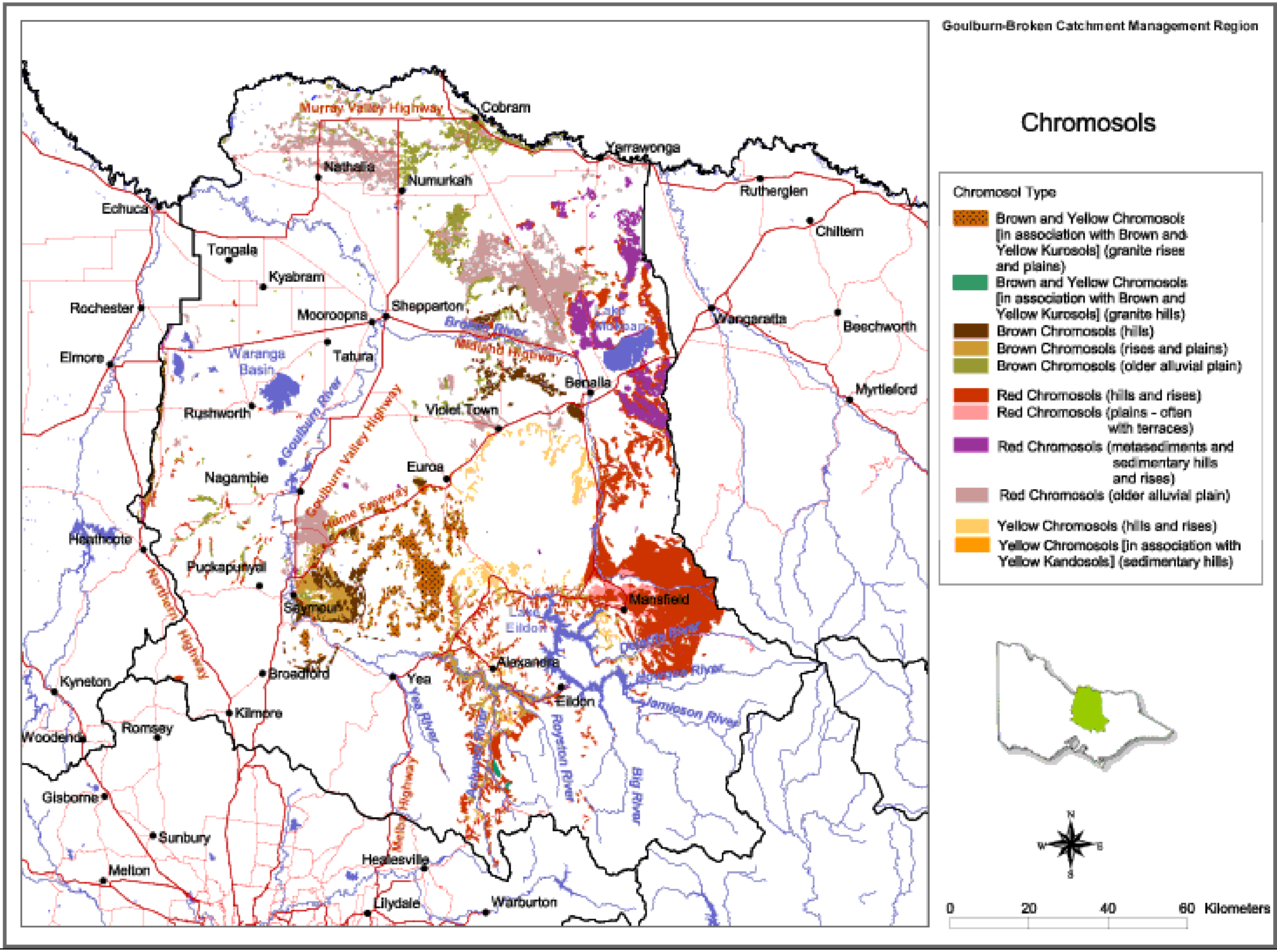
Red Chromosols are found on the Riverine Plains north and east of Benalla, particularly in the Devenish area. Here, the surface soils are often sandy with a variable depth to the subsoil which can be quite permeable. This might be associated with the surrounding granitic areas which have supplied the source material being sand and clay. Similar soils also occur on an outwash fan north of Avenel.

The other major occurrence is in the Mansfield area where the underlying parent material (i.e. Carboniferous sediments) imbues its colour into the soil. However, this area also has some occurrences of Mottled Brown Chromosols as well as black earths and clay soils, depending on landscape position and lithology. The surface soils are silty and some of these soils can be dispersive.

Brown and Yellow Chromosols

Brown and Yellow Chromosols generally have poorer drainage than the Red Chromosols and have either whole-coloured or mottled subsoils (B horizons). Surface horizons are often fine sandy or silty and can be dispersive and result in reduced infiltration. This occurs due to hardsetting of the surface soil on drying and reverting back into a liquid state when there is a small increase in moisture content. Some of these soils may also be sodic in the deeper subsoil and be prone to land degradation (e.g. in the area east of Seymour).

Brown and Yellow Chromosols occur in association with Kandosols in the southern parts of the region and with Kurosols in the granite areas east of Seymour.


Goulburn-Broken Catchment Management Region
Chromosols
Chromosol Type
Brown and Yellow Chromosols [in association with Brown and Yellow Kurosols] (granite rises and plains)
Brown and Yellow Chromosols [in association with Brown and Yellow Kurosols] (granite hills)
Brown Chromosols (hills)
Brown Chromosols (rises and plains)
Brown Chromosols (older alluvial plain)
Red Chromosols (hills and rises)
Red Chromosols (plains - often with terraces)
Red Chromosols (metasediments and sedimentary hills and rises)
Red Chromosols (older alluvial plain)
Yellow Chromosols (hills and rises)
Yellow Chromosols [in association with Yellow Kandosols] (sedimentary hills)
0 20 40 60 Kilometers
Cobram
Yarrawonga
Rutherglen
Chiltern
Nathalia
Numurkah
Echuca
Tongala
Kyabram
Rochester
Mooroopna
Shepparton
Wangaratta
Beechworth
Elmore
Tatura
Benalla
Myrtleford
Rushworth
Violet Town
Nagambie
Euroa
Heathcote
Puckapunyal
Seymour
Mansfield
Alexandra
Broadford
Yea
Kyneton
Kilmore
Eildon
Woodend
Romsey
Gisborne
Sunbury
Melton
Healesville
Lilydale
Warburton
Murray Valley Highway
Waranga Basin
Goulburn River
Broken River
Midland Highway
Goulburn Valley Highway
Hume Freeway
Northern Highway
Lake Eildon
Delatite River
Howqua River
Jamieson River
Yea River
Royston River
Big River

Kurosols

http://vro.dpi.vic.gov.au/dpi/vro/gbbregn.nsf/pages/soil_soil_gbb_kurosols

Kurosols are soils that display a strong texture contrast between surface (A) horizons and subsoil (B) horizons. The upper part of the subsoil is strongly acid (i.e. pH <5.5). Using the Australian Soil Classification, Kurosols can be grouped further (Suborder) based on the colour of the upper 20 cm of the subsoil (i.e. into Red, Brown, Yellow, Grey and Black). These can be further differentiated (into Great Groups) based on subsoil characteristics such as the nutrient level capacities and ratios.

Kurosols occur predominantly in the uplands where rainfall is higher and consequently so is the leaching. There are also minor occurrences north of Seymour. In the Goulburn Broken region, Red Kurosols occur at higher elevations and areas of higher rainfall, such as in the Strathbogie Ranges and south east of Alexandra. Yellow and Brown Kurosols occur mainly in the granite areas to the south of Euroa and to the east of Seymour.

Yellow Kurosol near Ruffy

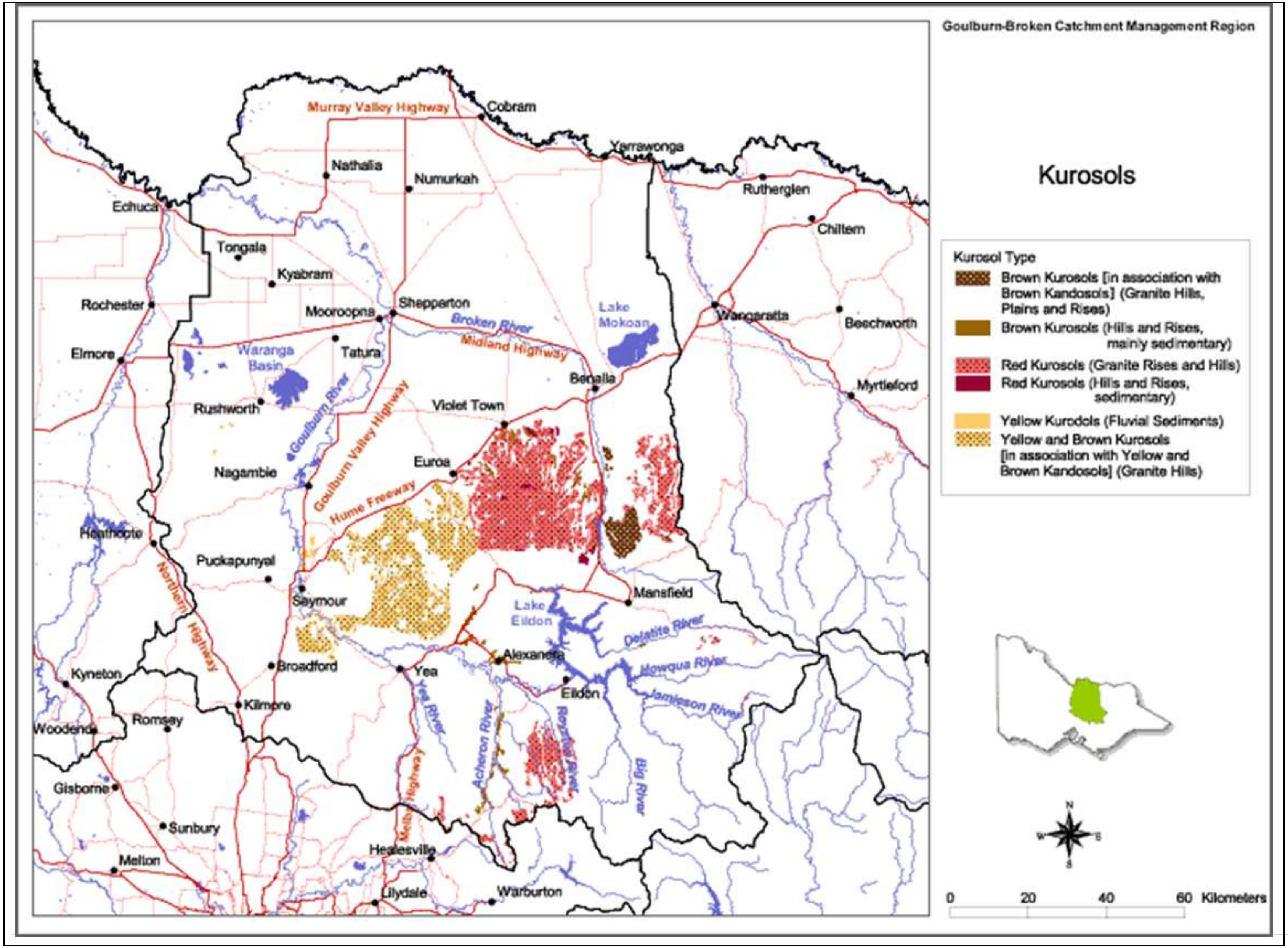
Red Kurosols

Red Kurosols are found in the eastern Strathbogie Ranges, also east of the Strathbogie Ranges and probably an area south east of Alexandra at higher elevations. These soils tend to have strongly structured subsoils but a poor nutrient holding capacity given their high acidity. However, the surface horizons are often organic matter rich giving the medium textured soils structure which aids drainage. As with most red soils they tend to be whole coloured in the upper subsoil at least.

Brown and Yellow Kurosols

Brown and Yellow Kurosols are associated with granite areas south of Euroa and east of Seymour. These soils typically have a sandy loam to sandy clay loam surface horizon and a bleached subsurface (A2) horizon. These surface horizons overlie a light medium to medium clay strongly acid subsoil horizon.

They are also associated with Tertiary gravel deposits north of Seymour. The surface horizons are sandy apart from an organic matter accumulation on the surface. The subsoil horizons are mottled and there are variable amounts of gravel within the main soil body (i.e. solum) as well as in the parent material.


Goulburn-Broken Catchment Management Region
Kurosols
Kurosol Type
Brown Kurosols [in association with Brown Kandosols] (Granite Hills, Plains and Rises)
Brown Kurosols (Hills and Rises, mainly sedimentary)
Red Kurosols (Granite Rises and Hills)
Red Kurosols (Hills and Rises, sedimentary)
Yellow Kurodols (Fluvial Sediments)
Yellow and Brown Kurosols [in association with Yellow and Brown Kandosols] (Granite Hills)
0 20 40 60 Kilometers
Murray Valley Highway
Cobram
Yarrawonga
Nathalia
Numurkah
Rutherglen
Chiltern
Echuca
Tongala
Kyabram
Rochester
Mooroopna
Shepparton
Broken River
Midland Highway
Lake Mokoan
Wangaratta
Beechworth
Elmore
Waranga Basin
Tatura
Benalla
Myrtleford
Rushworth
Goulburn River
Goulburn Valley Highway
Violet Town
Nagambie
Euroa
Hume Freeway
Heathcote
Puckapunyal
Northern Highway
Seymour
Mansfield
Lake Eildon
Delatite River
Alexandra
Broadford
Yea
Howqua River
Kyneton
Kilmore
Eildon
Jamieson River
Woodend
Romsey
Yea River
Acheron River
Big River
Gisborne
Sunbury
Melton
Healesville
Lilydale
Warburton

Kandosols

http://vro.dpi.vic.gov.au/dpi/vro/gbbregn.nsf/pages/soil_soil_gbb_kandosols

Kandosols are non-texture contrast soils (with little or gradual increase in clay content with depth) that have massive (i.e. weakly to non-structured) subsoils (B horizons). They are found mainly in the upland areas, often in association with Dermosols, Chromosols and Kurosols. These soils can vary from stony hardsetting soils to deeper friable soils. Some may almost be texture contrast and have a bleached subsurface (A2) horizon. Using the Australian Soil Classification, Kandosols can be grouped further (into Suborders) based on the colour of the upper 20 cm of the subsoil (i.e. Red, Brown, Yellow, Grey and Black). These can be further differentiated based on subsoil characteristics such as nutrient level capacities and ratios and the presence of carbonate or lime.

These soils are located in the Uplands, particularly close to the Dividing Range as well as the western Strathbogie Ranges and the Yea to Broadford area (where they are associated with Yellow Chromosols).

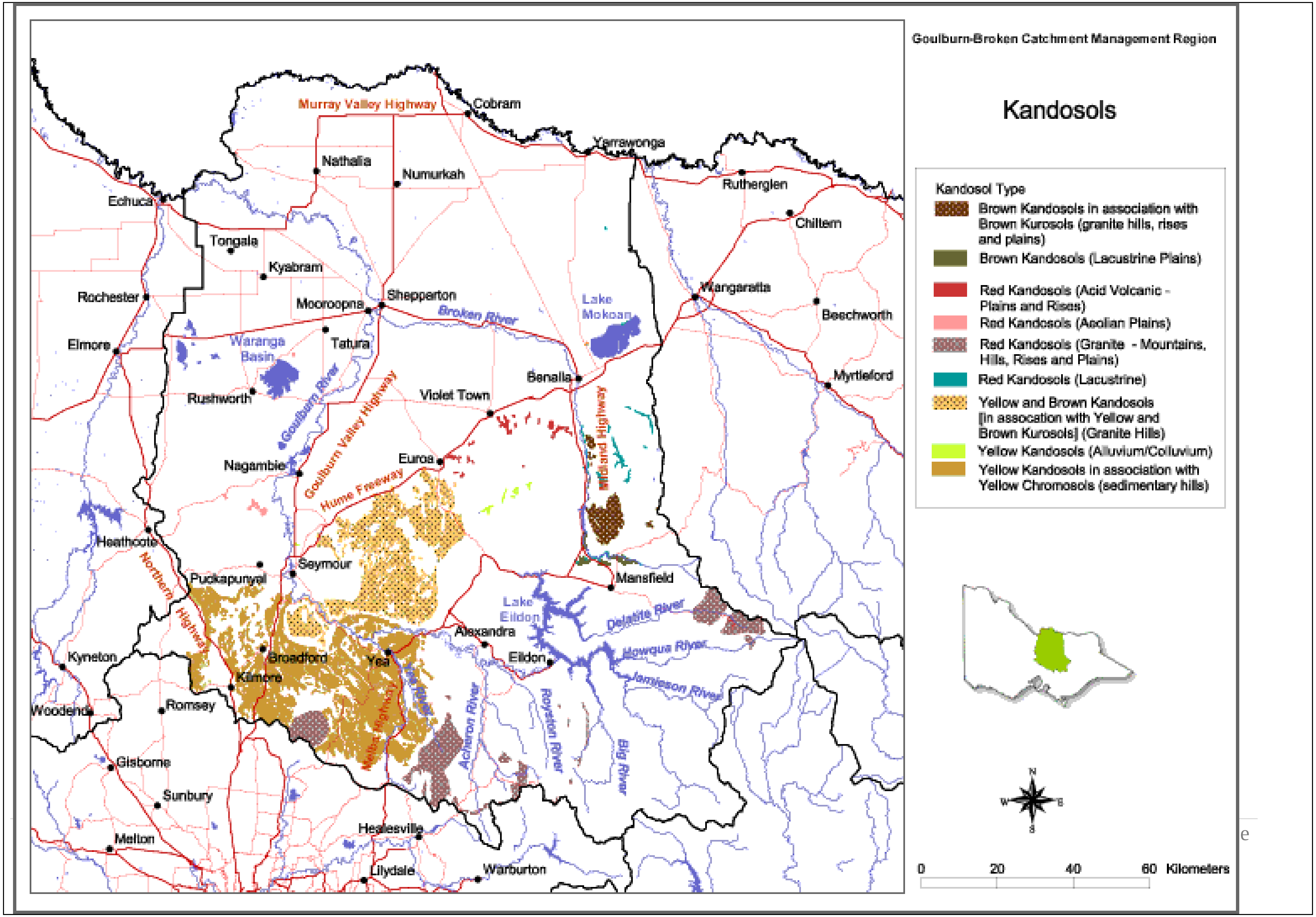
Red Kandosols

Similarly to the Red Dermosols, Red Kandosols are found in the higher rainfall areas of the region. The main locations are the Mt. Disappointment and Black Range (Narbethong) plateaus as well as west of Mt. Buller. These occurrences are associated with granitic parent material. Surface soils are generally organic loams (often fine sandy) and granular in structure. Subsoil (B) horizons are generally acidic and weakly to non-structured (earthy in appearance) reddish clay loams to medium clays. The field texture test can often underestimate clay content in these soils (i.e. they have a higher clay content than the hand texture would suggest) due to their clay composition. Red Dermosols and Ferrosols are similar in this way.

There are sometimes brown variants of this soil type in association with the red subsoil types. These soils are characteristically friable, unlike Kandosols in lower rainfall areas.

Brown and Yellow Kandosols

Brown and Yellow Kandosols are found primarily on the uplands of the western Strathbogie Ranges (where they occur in association with Brown and Yellow Kurosols), the Yea – Broadford area and to the north of Mansfield. The Red Kandosols are located generally in drier areas. Soil type characteristics range from having minimal profile development (but still >15% clay in the subsoil) to soils which may have hardsetting, bleached subsurface horizons with ironstone gravel (nodules/concretions) and noticeable colour change down the profile. Similarly to Dermosols there are often sequences of soil development associated with topographic position in the landscape and to some extent aspect (e.g. harder setting soils on drier aspects). Generally these soils are acidic to neutral. This may vary depending on their parent material (i.e. granite). Often these soils are associated with weakly developed soils (i.e. Tenosols) in granitic areas.



Goulburn-Broken Catchment Management Region
Kandosols
Kandosol Type
Brown Kandosols in association with Brown Kurosols (granite hills, rises and plains)
Brown Kandosols (Lacustrine Plains)
Red Kandosols (Acid Volcanic - Plains and Rises)
Red Kandosols (Aeolian Plains)
Red Kandosols (Granite - Mountains, Hills, Rises and Plains)
Red Kandosols (Lacustrine)
Yellow and Brown Kandosols [in assocation with Yellow and Brown Kurosols] (Granite Hills)
Yellow Kandosols (Alluvium/Colluvium)
Yellow Kandosols in association with Yellow Chromosols (sedimentary hills)
0 20 40 60 Kilometers
Murray Valley Highway
Cobram
Yarrawonga
Nathalia
Numurkah
Rutherglen
Echuca
Chiltern
Tongala
Kyabram
Rochester
Shepparton
Mooroopna
Broken River
Lake Mokoan
Wangaratta
Beechworth
Elmore
Waranga Basin
Tatura
Benalla
Myrtleford
Rushworth
Goulburn River
Goulburn Valley Highway
Violet Town
Midland Highway
Euroa
Nagambie
Hume Freeway
Heathcote
Northern Highway
Seymour
Puckapunyal
Mansfield
Lake Eildon
Delatite River
Alexandra
Kyneton
Broadford
Yea
Eildon
Howqua River
Kilmore
Jamieson River
Woodend
Romsey
Melba Highway
Yea River
Acheron River
Royston River
Big River
Gisborne
Sunbury
Healesville
Melton
Lilydale
Warburton

Dermosols

http://vro.dpi.vic.gov.au/dpi/vro/gbbregn.nsf/pages/soil_soil_gbb_dermosols

Dermosols are non-texture contrast soils that have structured subsoils (B horizons). They are found mainly in the upland areas, often in association with Kandosols which have massive B horizons. These soils can vary from stony hardsetting soils to friable deeper profiles. Some may almost have some texture contrast and a bleached subsurface (A2) horizon. Using the Australian Soil Classification, Dermosols can be grouped further (into Suborders) based on the colour of the upper 20 cm of the subsoil (i.e. Red, Brown, Yellow, Grey and Black). These can be further differentiated (into Great Groups) based on subsoil characteristics such as the nutrient level capacities and ratios and the presence of carbonate or lime.

The major occurrences of Dermosols are on the uplands. There are some on the Strathbogie Ranges, but they are mainly found in the moister areas closer to the Dividing Range as well as the Alexandra/Eildon area.

Red Dermosols

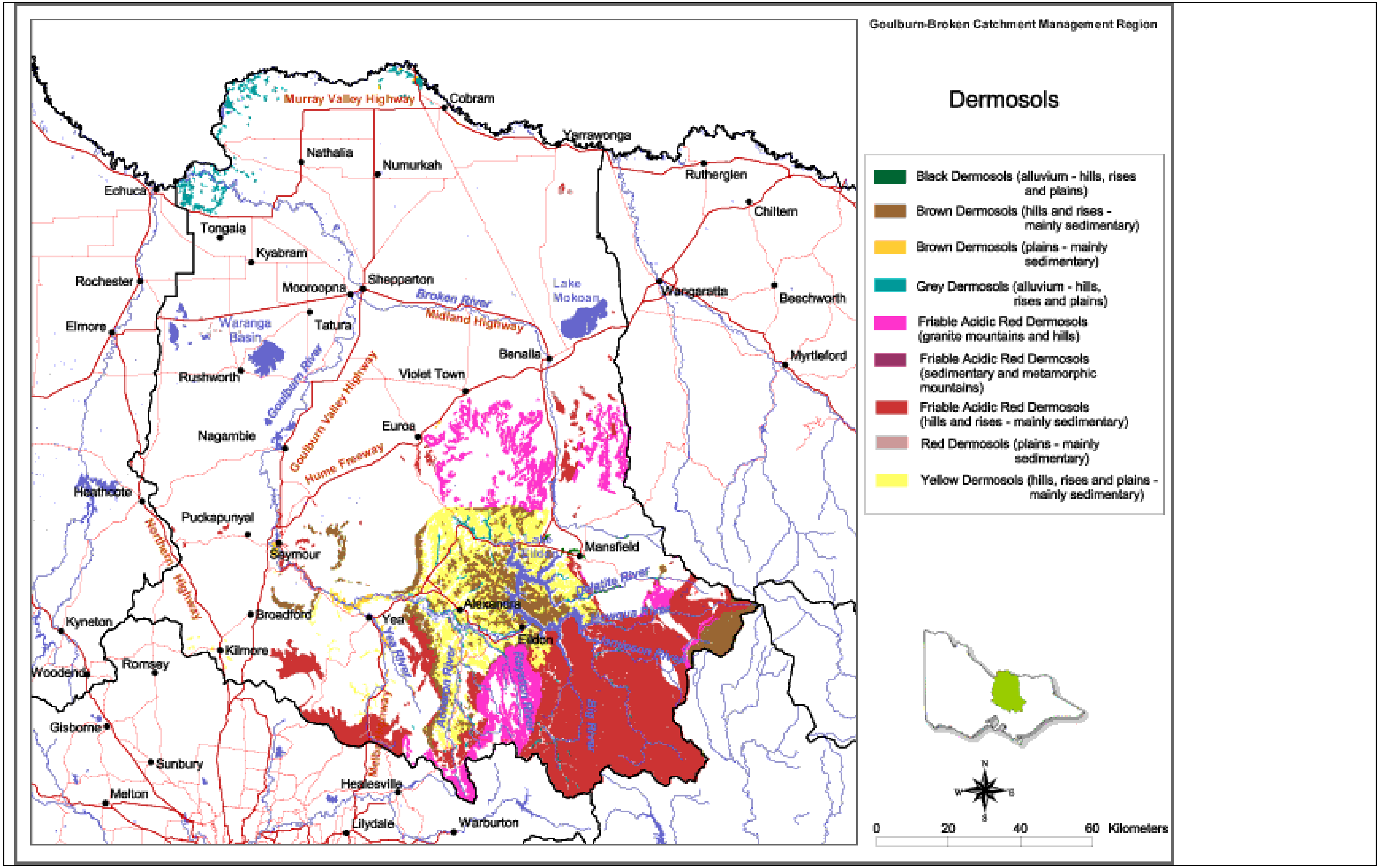
Red Dermosols are located closer to the Divide in the wetter climatic areas. These soils are moderately to strongly structured, usually with high organic matter levels in the surface horizons and have strongly acid subsoils (B horizons). They are also usually friable when moist.

There are often brown variants of this soil type in association with the red subsoils. These soils are characteristically friable unlike other Dermosols in lower rainfall areas. The field texture test can often underestimate clay content in these soils (i.e. they have a higher clay content than the hand texture would suggest) due to their clay composition. Red Ferrosols and Kandosols are similar in this way. In some cases, such as the Blue Range south of Mansfield, the colour of the subsoil has more to do with the colour of the parent material than the usual pedological processes.

Brown, Yellow and Grey Dermosols

Brown, Yellow and Grey Dermosols are generally located in the drier areas. However, they can vary from being less well developed (almost Rudosols) which are shallow and stony, to strongly developed - almost texture contrast with hardsetting, bleached subsurface horizons with ironstone gravel (concretions/nodules) and often mottled subsoils. The more developed profiles are typical of the sedimentary terrain around Alexandra and to some extent Yea. This highly dissected country often exhibits sequences (catenas) from the crests to the drainage lines, with shallower often less developed soils on the crests and deeper soils on the lower slopes. Many of these soils are sodic at depth and there are salinity problems in some areas. This contrasts with the structured and friable soils of the Goulburn River alluvial plain (flats).

There are also some occurrence of Dermosols on remnant rises and low hills north east of Euroa and on alluvial material on the Murray River plain.


Goulburn-Broken Catchment Management Region
Dermosols
Black Dermosols (alluvium - hills, rises and plains)
Brown Dermosols (hills and rises - mainly sedimentary)
Brown Dermosols (plains - mainly sedimentary)
Grey Dermosols (alluvium - hills, rises and plains)
Friable Acidic Red Dermosols (granite mountains and hills)
Friable Acidic Red Dermosols (sedimentary and metamorphic mountains)
Friable Acidic Red Dermosols (hills and rises - mainly sedimentary)
Red Dermosols (plains - mainly sedimentary)
Yellow Dermosols (hills, rises and plains - mainly sedimentary)
0 20 40 60 Kilometers
Murray Valley Highway
Cobram
Yarrawonga
Nathalia
Numurkah
Rutherglen
Echuca
Chiltern
Tongala
Kyabram
Rochester
Mooroopna
Shepparton
Broken River
Midland Highway
Lake Mokoan
Wangaratta
Beechworth
Elmore
Waranga Basin
Tatura
Benalla
Myrtleford
Rushworth
Goulburn River
Goulburn Valley Highway
Violet Town
Euroa
Nagambie
Hume Freeway
Heathcote
Northern Highway
Puckapunyal
Seymour
Mansfield
Broadford
Alexandra
Yea
Kyneton
Eildon
Kilmore
Romsey
Woodend
Gisborne
Sunbury
Healesville
Melton
Lilydale
Warburton
Big River

Rapid Soil Assessment Tool (RSAT)

The RSAT is an observational soil assessment field based tool designed to provide a semi-qualitative measure of the soil quality.

Landholder name:	Property address:	Date of assessment:
Enterprise type:	Pasture species:	Soil texture if known:
Landscape: Flat ( ) Hilly ( ) Gentle slope ( ) Mixture ( ) North slope ( ) South slope ( )		
Landholder's view on plant/animal productivity:		

Section 1 The following soil quality indicators are assessed on site.

Soil Quality Indicators	**Poor** **1------------2------------3**	**Medium** **4--------------5------------6**	**Good** **7--------------8-------------9**	**Assessment Card**								
				Poor			**Medium**			**Good**		
				1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Soil Characteristics												
1. Depth of A horizon	. <150mm in depth	150-450mm in depth	450mm or greater in depth									
2.. Soil structure	Few aggregates, powdery, clods, difficulty to cultivate	Some aggregates present giving fare structure, soil clods present but break with pressure	Good soil aggregation, friable with good structure, no clods evident									
3. Water stable aggregates Sampled from 100mm	Few if any water stable aggregates present after 1 minute contact with water-no dispersal	Some aggreagates are water stable after 1 minute contact with water-some dispersal	Many aggregates are water stable after 1 minute contact with water-all dispersal									
4. Soil crusting	Substantial surface crusting affecting water penetration and seedling emergence	Some crusting limited effect on seedling emergence and water penetration	Soil surface porous, no evidence of soil crusting									
5. Compaction Use of rod/penetrometer	Obvious soil compaction , hardpan, tight layers limiting root penetration (often	Some soil compaction, limiting root penetration and water movement. Metal rod,	No compaction evident, root development and water movement unrestricted.									

dependant on soil moisture & soil texture	horizontal growth), and water movement. Water logged layers may be evident. Metal rod, penetrometers will not penetrate under reasonable force	penetrometer penetrates with difficulty	Metal rod penetrometers penetrates easily.									
6. Organic matter	Pale bleached colour -little obvious organic matter in soil, compacted, cloddy, crusted on surface	Light brown soil colour-some plant material, some crusting and soil clods	Dark soil colour, decomposing plant material, friable structure									
Hydrological indicators												
7. Water infiltration	Water infiltrates very slowly, ponding evident, runoff obvious with signs of erosion.	Slow water infiltration with some ponding and runoff	Infiltration -excellent, no ponding little runoff except in excessive rainfall									
8. Erosion	Obvious soil erosion -rills, sheet and gully erosion evident, stones on surface.	Some signs of soil loss	No signs of soil loss									
9. Water logging	Obvious water logging in soil, water collects in low areas.	Some signs of water logging	No signs of water logging									
Biological indicators												
10. Root mat	Obvious fibrous root mat just below surface restricting root, water and oxygen penetration	Some indication of root mat	No evidence of root mat									
11. Plant root depth & development	Restricted root development (0-100mm), few fine feeder roots, some roots discoloured and rotting	Moderate root development (100-300mm) some fine feeder roots	Fibrous, dense and deep root systems (300-450mm)with good colour									

12. Nodulation	Poor nodulation on legumes- green yellow when broken open	Fair nodulation of legumes- colour pink/reddish when broken	Good nodulation of legumes with pink/red colour when broken									
13. Earthworms or earthworm channels, castings	Few signs of earthworm activity- no worm channels(< 4 worms)	Some worms evident, some worm channels and castings (4-8 worms)	Many worms evident, channels and castings (>8 worms)									
14. Macro soil life dung beetles, ants, termites other life forms	Few if any life forms, manure remains as deposited for some time	Some life forms including dung beetles visible - manure shows signs of decomposition within days	Dung beetles and other life forms prolific- decomposition of manure piles rapid									
15. Smell	Stagnant smell	Little or no smell	Fresh moist earthy smell									
Plant productivity												
16. Pasture cover & composition	Variable pasture productivity with stunted growth, less favourable species, herbage coverage <40%. Nutrient deficiencies maybe evident	Uneven productivity in pasture, herbage 40-70% coverage. Some less favourable species. Possible nutrient deficiency symptoms	Good pasture productivity with balanced species composition, herbage >70% coverage. No obvious nutrient deficiencies									
17. Leaf colour/ growth	Variable leaf colour, possible nutrient deficiencies, stunted growth	Some variation in leaf colour, no observable growth retardation	Even leaf colour, good growth									