

Healthy and productive soils – Soil Interpretation Workshop

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Soil provides the basic medium that supports all agricultural production. It holds water and nutrients for plants and soil organisms. It allows roots to explore deeper into the ground to extract water and nutrients from deep in the profile. Our management of the soil via cultivation, fertiliser and nutrient balance, maintenance of ground cover and organic matter dictates the sustainability of our natural resource.

Whilst there are many different philosophies of land management the foundational identification of soil form and function is common.

Monitoring soil chemical properties such as pH and plant available phosphorus (Colwell P) is useful to keep track of some properties that can change due to our management decisions, however often the greatest limitations to production are often found below the depths normally used for soil sampling. Failure to identify the fundamental limitation to plant growth will almost certainly result in inefficient use of inputs, loss of productivity and impaired profit.

Identification of soil properties that impact plant growth is easy with development of some simple skills.

The soil features of interest are:

- Layer identification (measure depth)

- Colour

- Texture

- Structure

- Consistence

- pH

- Salinity

- structural stability

- Biology

You will be trained in assessing these properties and interpreting soil profiles to support plant growth

LAYER IDENTIFICATION (MEASURE DEPTH)

Soil profiles contain layers (called horizons) that are identifiable by changes in colour, texture and structure. The depth of each layer can influence water holding capacity of the profile and root growth through the profile. The rate of change from one layer to the next can also influence water and root movement. With abrupt changes often causing problems.

The depth of layers is measured in centimetres from the surface (0 cm) to the middle of the zone of change to the next layer. The thickness of the zone of change, also known as the layer boundary is also noted; <2 cm abrupt, > 10 cm diffuse.

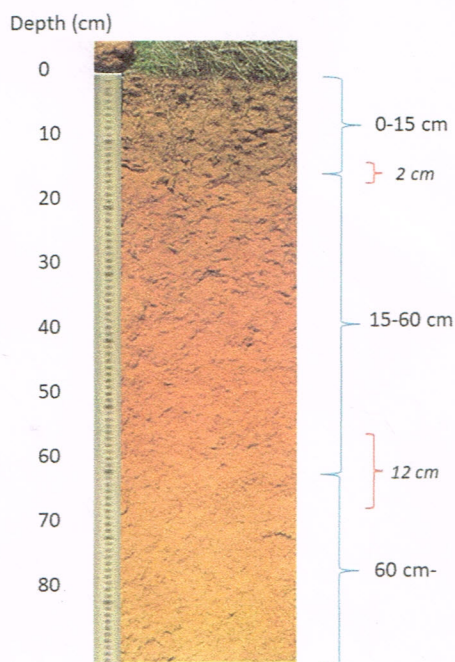
Often the thickness of the layers will be the cause of observed pasture variation within a paddock at different times of the year.

An example of layer depth identification:

The soil shown below has 3 layers: brown, red, orange

The middle layer is 45 cm thick and goes from 15 to 60 cm.

The thickness of layer change is 2 cm from layer 1 to layer 2, whereas the change is more diffuse between layers 2 and 3.



COLOUR

Soil colour is the easiest observable feature of soils to note. Two components in soil give colour: iron and organic matter.

Colours of iron:

When soils are well aerated the iron is oxidised to a **red** colour (just like rust= oxidised iron). When the soil spends a large part of each year in moist (not water logged) conditions the iron oxide looks **yellow**. **Orange** colours are a mixture of red and yellow and demonstrate that the soil experiences some dry and moist conditions. These iron oxides hold phosphorus in the soil (creating the PBI; phosphorus buffering index) and also act as a cementing agent to hold aggregates together.

Under waterlogged (anaerobic) conditions, the iron oxides lose their oxygen and become free iron which has a bluey-green colour called **gley**. You would have seen this colour in dams just under the water surface. Another indicator of water logging is a red colours along roots. This occurs because the free iron created in water conditions can move to the roots of growing plants and become oxidised (red rust colour) on the root surface where there is oxygen from the plant.

Where there is no oxidised or free iron, the soil will be very pale or white. In order to strip out the iron from soil it must have undergone extreme weathering over centuries or severe prolonged water logging, both of these scenarios result in the removal of many plant available nutrients.

Colours of organic matter:

Organic matter gives the soils dark colours. The more organic matter there is the darker the soil. When organic matter exists in an otherwise red/yellow/orange soil, the organic matter gives the soil a **brown** appearance. Soils that are pale brown have less organic matter than dark brown soils. **Black** soils have the greatest organic matter content. A red, yellow or white soil has very little or no organic matter.

Colour	Interpretation
Red	Well aerated, commonly dry
Yellow	Well aerated, commonly moist
Orange	Well aerated, not held as moist as yellow soil
Black	High organic matter content
Brown	Well aerated with organic matter – pale less OM, dark more OM
White	No iron oxide, no organic matter

TEXTURE

Texture is described by “texture classes”. These are word descriptions of the “feel” of the soil which represents the proportions of sand, silt and clay in the soil.

Sand is particles between 20 and 2000 micron (2mm). Sands allow good drainage but poor water retention. They do not hold nutrients.

Silt is particles between 2 and 20 micron. Silts are not very common in Australia due to age of soil.

Clay are particles less than 2 micron in diameter. Clays hold a lot of water due to the small pore space between particles. Clays are also negatively charged, so positive charged nutrients stick to them and avoid leaching loss. The name of positive charged nutrients end in “ium”, e.g. potassium, sodium, aluminium.

To determine texture:

Form a ball of moist soil by slowly adding water to soil in the palm of your hand. Remove any roots you find, break up all aggregates. Try to form a ball by rolling the soil between your two hands whilst making a circular motion with your hands.

Sands can not form a ball. Loams and clays will form a ball. Loams feel spongy, clays feel like plasticine. If silt is present, it will make the soil feel slippery (like engine oil) when working into a ball.

The ball needs to have the right water content for the next part of the texture determination. There should be a slight shine to the surface of the ball – this indicates the correct moisture content.

If too wet, roll the ball between your hands until it dries a little. If too dry (dull surface) add a few drops of water and form the ball again.

The texture class (the name for the texture) and the percentage of clay present can be determined by pushing the soil between your thumb and forefinger to form a ribbon.

The ribbon is to be about 2-3 mm thick, 2 cm wide and as long as you can make it. The length of the ribbon relates to the texture class – see table below.

Texture class	Ribbon (mm)	Approximate clay content %
Sands	<10	0-10
Sandy loam	15-25	10-20
Loams	25-40	20-30
Clay loam	40-50	30-35
Light Clay	50-75	35-45
Heavy Clay	>75	> 45



STRUCTURE

Structure is the shape of the aggregates. It can influence water infiltration, drainage, aeration and root penetration.

A good structure will create pores in the soil. Poor structure will allow few pores to be present.

Examples of common structure forms are:

Granular: small (<10mm) spherical, normally associated with high organic matter contents (in the topsoil). Many large pores will be present.

Blocky: larger (>10 mm), chunky with some pores between the aggregates, but fewer pores than granular. Normally found in the subsoil where more clay is present

Platy: Plate like structures that are longer horizontally than vertically. These are commonly caused by management – compaction due to stock or machinery. Few pores are present and roots often have to find a way around plates – inefficient root growth.

Massive: There is no structure = no aggregates. The soil is just one lump. Often restricts root growth

Single grained: There is no structure = no aggregates but this is due to no binding of soil particles (eg beach sand).

CONSISTENCE

This is a measure of how hard or soft soil aggregates are when you place a 2 cm diameter aggregate between your thumb and finger and try to break the aggregate.

When the soil is dry we use words such as soft, hard, very hard to describe the force.

Under moist conditions we use the words friable and firm

This property is quite subjective but gives an indication of likely root growth limitations.

Dry	Moist	force
soft	Very friable	Breaks under gentle pressure
Slightly hard	Friable	Moderate pressure
hard	Firm	Some resistance
Very hard	Very firm	Barely crushable with hands
Extremely hard	Extremely firm	Cannot be broken by hands

SOIL PH

Soil pH influences nutrient availability, root and soil organism growth and function. Soil pH is a measure of the acidity or alkalinity in a soil. The "H" of pH stands for hydrogen ions (H^+), these are the acid. The more H^+ there are the lower the pH value.

Soil pH is easily measured in the lab using a weak salt solution (Calcium chloride = $CaCl_2$) which aims to match the likely salt concentration created by normal nutrient loads of most topsoils. That is the pH measured in calcium chloride (pH_{Ca}) is likely to be the actual pH experienced by the plant in the soil.

Soil pH can also be measured in water (pH_w). This is a similar process but as plants do not grow in pure water, the values are not what the plant experiences. For a given soil, the pH measured as pH_{Ca} will be lower than the pH_w . The difference is normally between 0.6 and 0.8 pH units.

Soil pH can be measured in the field using a colorimetric kit. These kits are comprised of a pH indicator that changes colour at different pHs, a white powder that soaks up the colour so it can be seen against a wet soil and a card that has a legend of colours for each 0.5 pH unit progression from 4 to 9.5 and a set of instructions to use the kit. These kits provide estimates of soil pH as measured in water.

SALINITY

Soil salinity is a measure of how much salt there is in a soil. It can be measured in the field with the use of a hand held electrical conductivity (EC) meter.

STRUCTURAL STABILITY

Ideally soil aggregates will maintain their form when the soil gets wet. This will allow the pores present to allow the movement of air and water through the soil. If the soil is not structurally stable, the aggregates will fall apart and the large pores will be lost and small pores can become blocked with soil debris created as by the loss of structure.

Structural stability is tested by placing small aggregates (1- 2 cm in diameter) gently into containers of rainwater, irrigation water or deionised water and watching to see changes instantaneously, within 5 mins and after a few hours.

Should the aggregate get wet but form is maintained the structure is considered stable and this is ideal.

If the aggregates break into smaller aggregates and the water will remain clear – This is known as slaking. It is a form of structural breakdown.

If the small aggregates then go on to continue to break into individual sand, silt and clay particles, the water will become cloudy as the clay particles move within the water – This is known as dispersion. This is the worst form of structural breakdown.

Note: when doing the test for structural breakdown great care must be made to not move or knock the container holding the water and aggregates.

Slaking can be overcome with the application or build up of fresh decomposing organic matter. Dispersion may be addressed with the application of gypsum.

BIOLOGY

Soil biology can be visually assessed by noting the presence of worms, ants and beetles. Observation of microorganism is possible with the use of microscopes but it is easier to note two observations of their function:

- 1) Has there been an accumulation of organic matter that shows that breakdown is limited?
and,
- 2) As the profile description process identified any limitation to biology (eg water logging, salinity, pH extremes, lack of organic matter)

There are three components of a fertile soil: chemical, physical and biological. Problems with any two of these will impact on the third. So a soil with no physical or chemical limitations should have no biological limitation.

Location: _____ Landscape: _____ Vegetation: _____

History: _____ Performance: _____

Feature / Layer ID	Layer 1	Layer 2	Layer 3	Layer 4
Layer Depth (cm)				
Depth of change to next layer (cm)				
Colour				
Texture				
Ribbon (cm), texture				
Structure				
Consistence				
pH				
Salinity				
structural stability				
Biology				
Other info:				