Land

Use this section to find out more about the geology, topography and soils of our district.

What is in this section?

This section contains an overview of the geological history of the Central Tablelands Landcare district, the development of soils, References for further information.

Land Snapshot - Overview

Geology

- ***Geology is the study of the Earth.***
- ***Of most interest to geologists is the Earth's crust.***
- ***The Earth's crust averages 17km thick over the whole planet.***

Topography

- ***Topography affects climate, soil types, movement of surface water and vegetation.***

Soils

- ***Soil is a living layer.***
- ***The main difference between nonsoil (dirt) and soil is living organisms.***
- ***Formation of soils is influenced by a number of factors, including climate, topography, parent material, time and vegetation.***

Land Classes

- ***"Land capability describes the ability to land to sustain a type of land use without causing it permanent damage. If land is used beyond its capability it will lose production and degrade."***
- ***Land is classed according to the most appropriate uses, to prevent land degradation such as soil erosion.***

Contents

1 Geology

Introduction to geology – what is it?

Geology is the study of the Earth, including the study of the processes that have shaped the Earth's surface, the ocean floors, and the interior of the Earth. It is more than just the study of the Earth as we see it today, but includes the history of the Earth as it has evolved to its present condition. The Earth is about 4.6 billion years old. It has evolved during this time and will continue to evolve in the future.

Geology in our district

Landform and geology in the Central Tablelands of NSW has been strongly influenced by a series of volcanic and sedimentary periods followed by folding and faulting.

Australia is divided into three major geological regions, known as cratons, based on tectonic plate divisions. These regions reflect the crustal development of the continent and the present-day pattern of crustal structure is thought to be representative of ancient patterns as the individual cratons haven't moved relative to each other since the time of their formation and have thus developed independently of any tectonic plate movements.

The NSW Central Tablelands fall into the Eastern Craton, and is part of the further subdivision known as the Lachlan Fold Belt.

The Lachlan Fold Belt

The Lachlan Fold Belt is estimated to have formed in the Cambrian to Carboniferous eras and covers an area of 375 000km^2. Its physiography is described as having tablelands stepping down to the west, upland plains, high upland and hill chains and dissected high plateaus.

The Lachlan Fold Belt extends from central and south-eastern NSW to central and eastern Victoria, and there are also uplifted sections in northern Queensland and the north-east of Tasmania. There are three major lithotectonic groups:

- Greenstone belts of Early-Middle Cambrian
- Ordovician-Silurian turbidite fans deposits; and the
- Complex sedimentary, volcanic and plutonic associations of early-mid Silurian to Late Devonian-early Carboniferous.

The Lachlan Fold Belt is the most geologically complex in New South Wales due to a series of major orogenies (mountain formation particularly by thrusting and folding), periods of granitic intrusions and the Belt's long history of volcanic activity. These events took place during the Ordovician through to the Tertiary periods.

Geological Zones of the Central Tablelands Landcare district

Our area can be divided into seven distinct geological zones:

- Molong Geanticline
- Bathurst and Gumble Granite Intrusions
- Cowra Trough
- Abercrombie Oberon Zone
- Hill End Trough
- Tertiary Volcanics
- Upper Devonian Fan Deposits

Table 5.1.2 Geological Zones of the Central Tablelands Landcare Area

Zone	**Molong Geanticline**	**Hill End Trough**	**Tertiary Volcanics**	**Bathurst and Gumble Granite Intrusions**	**Cowra Trough**	**Capertee Rise**	**Upper Devonian Fan Deposits**	**Abecrombie-Oberon**
Period	Ordovician	Silurian to Devonian	Tertiary	Silurian to Devonian	Silurian to Devonian	1.Ordovician 2.Silurian to Devonian	Upper Devonian	Ordovician-Silurian
Environment	Volcanic arc and shallow water sediments originating from intermediate volcanics and some coral reefs	Deep water acid volcanic deposits and marine sedimentation	Basic to intermediate volcanics	Massive granite intrusions	Sedimentation in a marginal sea with small amounts of volcanic activity	1.Intermediate to basic volcanic activity 2.Marginal sea sedimentation in the Silurian and shallow marine sedimentation and coral reefs in the upper Devonian	Terrestrial sedimentation	Continental shelf sediments with associated intermediate volcanics
Rock types	Andesites and associated shales, siltstones, tuffs with some limestones	Slate, shales, quartz grey-wackes	Trachytes, basalts, diorites	Granite and diorites	Shales, porphyry, siltstones, sandstones, limestone	Andesites, greywackes, shales, limestone	Sandstone, conglomerate, shale, siltstone	Quartz and feldspathic, slates, tuffs, limestones, andesites, greywackes
Dominant soils	Chocolate soils, non-calic brown soils, Eucharozems, chocolate soils, red podzolic, red earths, terra rossas	Red podzolic, yellow solodic soils and shallow soils	Krasnozems, euchrozems, chocolate soils, cracking clays, red and yellow podzolic, red earths, yellow solodic soils	Siliceous sands, shallow soils, yellow and red podozolic, red and yellow earths	Non-calic brown soils, yellow solodic, red and red-brown earths, yellow and red podozolic	Red and yellow podozolic, Kasnozems, shallow soils, red and yellow earths	Non-calic brown soils, Red and yellow podzolic, shallow soils	Red and yellow podzolic, red and yellow earths, terra rossa on limestones
Examples of localities	Molong, Borenore, Lyndhurst, Errowanbang	Mullion, Clergate, Peel, Hill End	Orange, Spring Hill	Bathurst, O'Connell, Perthville, Gumble	Manildra	Yetholme, Turon	South west of Molong	Triangle Flat, Oberon, Hobbies Yards.

Source: Kovack and Lawrie 1990 Soil Landscapes of Bathurst

The Earth's crust – minerals and rocks

The elements of the earth's crust are organised into compounds that we recognise as minerals. A ***mineral*** is a naturally occurring, inorganic substance, usually possessing a definite chemical composition and a characteristic atomic structure. Vast numbers of mineral varieties exist, together with a great number of their combinations into rocks.

Rock is broadly defined as any aggregate of minerals in the solid state. Rock comes in a wide range of compositions, physical characteristics, and ages. A given rock is usually composed of two or more minerals, and usually many minerals are present. There are a few rock varieties, however, that consist almost entirely of one mineral. Relative to human standards, most rock in the earth's crust is extremely old, with the time of formation ranging back many millions of years. Rocks are, however, continuously being formed.

There are three major rock classes, differentiated by the way they form. They are ***igneous***, ***sedimentary*** and ***metamorphic rocks***.

Igneous rocks

Igneous rocks are formed by the crystallisation of minerals in a high-temperature molten state, i.e. magma. Thus, they are formed by the actions of volcanoes, and they make up the vast bulk of the Earth's crust.

Plutonic or ***intrusive igneous rocks*** are those that are formed by the solidification of magma beneath the surface of the Earth. Intrusive igneous rocks have a coarse-grained texture and result in the growth of large mineral crystals. An example of this rock type is **granite**.

Volcanic or ***extrusive igneous rock*** is produced by the solidification of lava ejected from volcanoes on the Earth's surface. The resulting rock, such as **basalt**, has a fine-grained texture as a result of the rapid cooling of the lava and the subsequent very small mineral crystals.

Sedimentary rocks

These are layered accumulations of mineral particles derived in various ways from pre-existing rocks.

Over long periods of time, following the movement of material (by water or wind) to locations where permanent accumulation is possible (shallow seas, inland seas and lakes) physical or chemical changes occur resulting in the sediment becoming compacted and hardened, producing sedimentary rock. *Lithification* is the name given to this process of compaction and hardening.

Sedimentary rocks characteristically have a *layered arrangement*, comprised of alternating or interlayed layers of different textual composition.

Examples of sedimentary rocks include:

- **Shale**, which is the most abundant of the sedimentary rocks, formed from clay mud.
- **Sandstone**, formed of sand grades of sediment, cemented into rock by silica or calcium carbonate.

- **Limestone**, which is the most common of the carbonate rocks (of which one form is chalk), is comprised of skeletons of microscopic plankton deposited in shallow water.
- **Gypsum**, a layered rock of calcium sulfate, formed where seawater is evaporated in shallow bays and gulfs.

Metamorphic rocks

The word *metamorphism* is derived from Greek (Meta = change, Morph = form), meaning to ‘change form’. Metamorphic rocks are either igneous or sedimentary rocks that have been physically and chemically changed by the application of heat (greater than 200°C) and high pressures (greater than 300Mpa) during mountain-making events (described in more detail later in this section). The process results in rocks that are so altered in appearance and structure as to be classified as metamorphic rocks.

Metamorphism typically results in new textures and structures, and the mineral components of the parent rock are often reconstituted into different mineral varieties. **Quartzite** is formed by the recrystallisation (growth in crystal size) of pure quartz **sandstone** as a result of heat and pressure. **Marble** is the metamorphic equivalent of **limestone**.

Geological Time

The timeframes over which geological changes occur are very long by human standards and in order to fully understand geological evolution it is important to be aware of geological timeframes.

Geological time is divided into **eras**, **periods** and **epochs**.

The **Precambrian Era** is the oldest, commencing from the creation of the Earth. Following that there are three Eras: **Paleaozoic**, **Mesozoic** and **Cenozoic** in which the evolution of life on land and in the sea occurred.

Throughout the entire course of geological history major periods of fold-mountain formation occurred, known as **orogenies**. The orogenesis episodes were brief but intense during which tectonic activity resulted in the crumpling, buckling and deformation of sediments within geosynclines. These sediments are compressed into long, linear mountain chains (orogens). Volcanic activity often accompanies orogenies.

Nearly all of the landforms seen today were produced since the start of the **Cenozoic Era** 66 million years ago, making it a particularly important era. It is comparatively short and is subdivided directly into **epochs** but, although an archaic system, the **Periods** listed in the following table (*Tertiary* and *Quaternary*) are still used widely by many geologists. The epochs in the Cenozoic Era (*Holocene* and *Pleistocene* etc.) are well recognised and accepted by geologists worldwide, although different sources have varying names for epochs in other eras.

The ages of rocks, and the ages given in the following table have been determined through the chemical analysis of radioactive elements in rocks. Although there can be small errors in determining the age of rocks, the ages are well established and recognised by geologists.

Table 5.1.1. The Geological Time Scale (adapted from Strahler and Strahler 1992, and Branagan and Packham 1970).
m.y. = million years, b.y. = billion years

Era	Period		Epoch	Duration	Age (years before present) *	Major events and features
CENOZOIC *Age of Mammals*	Quaternary		Holocene	10,000 years		12,000 years ago - End of last glacial. Sea levels rise. Flooding of the land bridge across Bass Strait.
	Quaternary		Pleistocene	2 m.y.		Modern humans arise, begin migrations. Glaciation of Kosciusko.
	Tertiary	Neogene	Pliocene	3 m.y.	2 m.y.	
	Tertiary	Neogene	Miocene	19 m.y.	5 m.y.	Australia is approximately in present-day position.
	Tertiary	Paleogene	Oligocene	13 m.y.	24 m.y.	
	Tertiary	Paleogene	Eocene	21 m.y.	37 m.y.	Tasmania is the last part of Australia to separate from Antarctica, completing the break up of Gondwana.
	Tertiary	Paleogene	Paleocene	8 m.y.	58 m.y.	Volcanic activity in Australia.
MESOZOIC *Age of Reptiles*	Cretaceous			78 m.y.	66 m.y.	New Zealand is separate from Gondwana. Wide spread of dinosaurs followed by extinction.
	Jurassic			64 m.y.	144 m.y.	Gondwana starts to break apart.
	Triassic			37 m.y.	208 m.y.	
PALEOZOIC *Ancient Life* *(Insects and Amphibians)*	Permian			41 m.y.	245 m.y.	Mass extinction, 90% of organisms die. Reptiles rule the Earth. Pangaea separates into Laurasia and Gondwana. Coal (NSW, Qld).
	Carboniferous			34 m.y.	286 m.y.	First true reptiles. Glaciation and last folding of Lachlan Geosyncline.
	Devonian			48 m.y.	360 m.y.	Spiders, mites and amphibians.
	Silurian			30 m.y.	408 m.y.	First plants and insects on land. Intense volcanism in NSW.
	Ordovician			67 m.y.	438 m.y.	Primitive life on land, vertebrates in the ocean.
	Cambrian			65 m.y.	505 m.y.	Multi-cellular life. Shallow sea in far west of NSW.
PROTEROZOIC (Precambrian) *Early Life* *(eg Algae)*	Late Precambrian			0.3-0.4 b.y.	570 m.y.	
	Middle Precambrian			0.6-0.8 b.y.	0.9-1.0 b.y.	
	Middle Precambrian			0.7-0.9 b.y.	1.6-1.7 b.y.	2.5 b.y. Earliest known life.
	Early Precambrian			0.9-1.0 b.y.	2.4-2.5 b.y.	3.6-3.8 b.y. Oldest dated rocks.
	AGE OF THE EARTH				4.6-4.7 b.y.	
	AGE OF UNIVERSE				17-18 b.y.	

How does geology affect us?

The rocks, minerals and topography of our area affect the soil types and properties, having a strong influence on the vegetation that will be supported and the local economy and social structure of an area. The topography also influences the climate.

Geological history

Volcanism

Volcanoes are openings in the Earth's crust from which molten lava, volcanic gases, steam and other materials are ejected from below the crust. The form of their peak, whether cone-shaped or dome-shaped is determined by the nature of the materials ejected from them when they erupt. Volcanoes are characterised according to their level of activity.

Table 5. .. Levels of volcanic activity (from Earth Science Australia and Strahler and Strahler, and www.volcanolive.com)

Volcano activity	Characteristics	Examples
Active	Volcanologists use the term 'historically active volcano' (Holocene volcano), which is one that has shown eruptive activity in the last 10 000 years. An active volcano need not be in eruption to be considered active. Currently there are about 600 active volcanoes on Earth considered active, and each year 50-60 actually erupt.	***Mt St Helens*** (USA), had not erupted for 123 years before reawakening in 1980. ***Mt Pinutabo*** (Philippines), had been dormant for more than 400 years before erupting in 1991. ***Mt Vesuvius*** (Italy), was considered extinct prior to its devastating eruption in 79 A.D., which buried the city of Pompeii. Has shown signs of activity over the last few decades. ***Mt Erebus*** (Antartica), world's southernmost historically active volcano. Activity has been recorded from 1912 to recent years.
Dormant	Somewhere between active and extinct. One that hasn't shown eruptive activity within recorded history, but shows evidence of geological activity. The lifetime of a volcano may be in the order of a million years. Dormant volcanoes can suddenly become active so are considered the most dangerous.	***Mount Gambier*** (South Australia), last erupted in 2900 B.C. Tremours still occur.
Extinct	No longer active and hasn't erupted in historical times. Is usually deeply eroded and shows no signs of recent activity. Their original relief form may have been almost obliterate or considerably diminished by denudation.	***Mt Canobolas***, last believed to erupt 11-13 million years ago. ***Mt Warning*** (NSW), which last erupted 20 million years ago. ***Kilimanjaro*** (Tanzania).

All of the volcanoes along the Australian belt of volcanism have not erupted for more then 5000 years.

The last eruption from Mt Canobolas is estimated to have occurred between 11 and 13 million years ago.

Weathering

Rock materials that are close to or at the earth's surface are subject to various processes which cause them to decompose. Weathering is the term which describes the combination of all natural processes that are a part of the breaking down of the earth's mantle. There are three main types of weathering – chemical, mechanical and organic weathering.

Rocks that have begun to break down due to weathering processes are called regolith. When regolith is broken down into detached mineral particles it becomes the parent material for the formation of true soil. True soil is a surface layer of material capable of supporting the growth of plants.

Erosion

Erosion is where surface materials become worn away and transported. The difference between erosion and weathering is weathering is where there is breakdown but no transportation occurs. There is also a difference between erosion which takes place under natural conditions and erosion which is caused due to human activities. Natural, or geological erosion, is generally a slower process than the erosion in landscapes which have been altered by people.

Deposition

Deposition is the laying down of material that has accumulated following:

- erosion and transportation by physical processes such as wind, ice, water, ocean waves and currents; or
- the remains of former organisms (coal, peat, coral); or
- evaporation.

Sedimentation

Sedimentation occurs after a depositional event where materials become layered.

Folding

Folding occurs where compression forces in the earths crust causes the rocks and surface material to fold.

Faulting

A fault is where there is a fracture line in the earth's crust and this area is subject to pressure. There are many ways the land can move either side of this fault line. Sideways, upwards or downwards. The angles of this movement can then produce various types of landscapes.

Metamorphics

Metamorphism is where areas of the earth's crust are subjected to such high temperatures and/or high pressure that irreversible changes take place in the parent material.

Our geological history and environment

"Outline the tectonic provinces (SGS) in the district. Outline the faults in the district explaining geological groups."

The geological history of the Central Tablelands is influenced by many formation, weathering and erosion processes and forces.

The Canobolas Mountains are made up of volcanic and intrusive rocks. It is thought that the eruptions of the various peaks happened over such a long period of time that there was some rock weathering between eruptions. Because the volcanic activity has happened relatively recently the volcanic rocks have not formed much of the soils there. The rocks from the volcanic eruptions are moderately rich to poor in silica and with feldspars commonly containing sodium and potassium, rather than calcium. The lavas vary from trachytes (several types) to andesitic basalts and basalts. The intrusive rocks vary from porphyries to dolerites. Associated with lavas are large quantities of agglomerate and tuff formed during explosive eruptions.

2 Topography

Our landscapes and slopes

Topography is the surface features of the Earth's surface. It is largely the result of an area's geological history and the differences in resistance to weathering of the various rock types. Weathering is affected by the geological activity (and geological materials), climate and vegetation. Conversely, topography can also have an influence on climate, soils, vegetation and land use.

Topography of the Central Tablelands Landcare district

The Central Tablelands Landcare district can be divided into two main geographic regions, the Central Tablelands and the western plains and slopes east of Mount Canobolas.

The Tablelands are comprised of several high plateaus. Altitudes of over 1200m can be found in the vicinity of Yetholme, Mount Lambie, Black Springs, and the highest point, Mount Canobolas (1398m). These areas are usually rugged slopes and left to native timber or forestry.

The Granite hills in the Bathurst Basin are markedly lower with altitudes around 700m. This sunken basin forms part of the Macquarie River Valley and the Bathurst Plain.

In the west of the region one can find the Harveys, Nangar, and Mandagery ranges. These ranges have steep to rolling hills with cliffs and escarpments reaching up to 740m.

The region is well-drained and has a large number of rivers and tributaries. These include the Macquarie which drains most of the region; the Fish, Campbells, Turon and Winburndale rivulet in the east; the Abercrombie to the south and the Bell, Belubula and Molong to the west.

Topography and Land use

Because of the area's complex geological history and diverse topographical features, slope plays a large part in determining land use. Slope is just one aspect used in determining land capability and classification, which is explained in '5.4 Land Classes' in this toolkit section.

Cropping is practiced on areas listed mostly flat (less than 3%). Most cropping takes place west of the Molong Geanticline and in the Bathurst Basin.

Grazing is the most common land use in the Central Tablelands Landcare District and is mostly practiced on slopes ranging from 10 to 30%.

The rugged to mountainous country (greater than 30%) is widely left to native timber or radiata pine plantations. Soils found on these slopes are shallow and attempts at clearing or cultivation or set stocking can lead to serious erosion.

Topography and Soils

The range of soils in the district is partly influenced by the area's topography. Slope affects soil drainage regimes as well as soil depth and rock outcropping. The steeper the slope, the less soil depth and greater rock outcropping.

Upper to mid slopes in the wetter eastern portion have well to moderately well-drained soils, grading to imperfectly to poorly drained soils on the lower slopes and depressions. Imperfectly to poorly drained soils are generally yellow, grey, or mottled yellow and grey while well-drained soils are red or brown.

The proportion of yellow to grey soils to red and brown soils depends on the area of land that is poorly drained and the parent material. Siliceous parent materials, siliceous granites and sandstones, have a much higher proportion of yellow-grey soils. Intermediate parent materials such as grandiorites and sedimentary rocks apart from sandstones seem to have higher proportion of red-brown soils. The more basic rocks like some basalts tend to be red-brown with lower slopes being comprised of black or dark coloured soils.

The separation of iron (Fe) and manganese (Mn) into nodules is common feature of seasonally waterlogged soils. Concentrations of these nodules can form impermeable pans. The Orange area soils contain a large amount of iron and manganese nodules and they can sometimes form thick dense pans, however they tend to be localised and don't affect the overall drainage conditions for the area.

Topography and Climate

Topography can have a strong influence on an area's climate. Areas of high and low altitude influence local temperatures and precipitation.

Precipitation occurs when warm, moist air cools and condenses, usually when rising. When an air mass is forced to rise to surmount a topographic barrier, its temperature begins to fall and it loses the ability to 'hold' onto moisture, and the resulting condensation is known as **orographic rainfall** (meaning 'relating to mountains'). By the time the air mass reaches the other side of the barrier it holds less moisture, creating a *rainshadow effect*, which is one of the main factors that influences the location of deserts. The Great Dividing Range on Australia's east coast greatly affects the precipitation to its west, and more locally Mount Canobolas has a strong influence on the area's rainfall patterns.

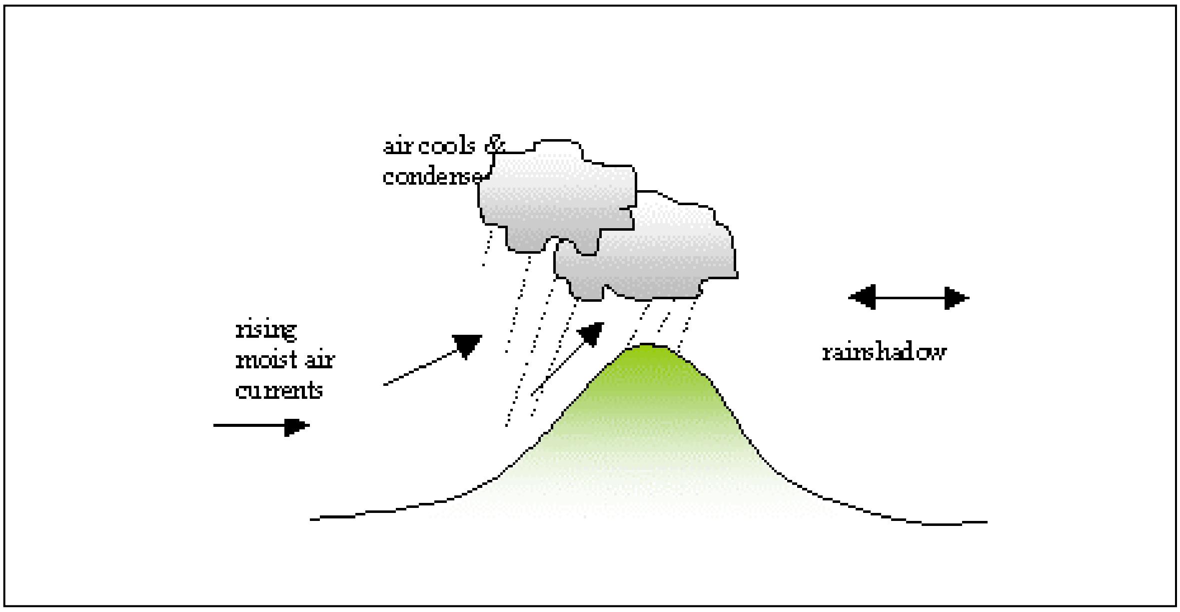


Figure 5.2. 2
Orographic precipitation and the associated region of rainshadow.

The climate around the Central Tablelands is also strongly influenced by topography and the movement of cold air. Cold air is dense and sinks into the lower lying areas. During the cooler months the concentration of this colder air increases the number of frosts in some areas. An example of this is the Bathurst basin has a higher incidence of frost in comparison with the surrounding higher altitudes.

Topography and Vegetation

As with soils and climate, topography can determine an area's vegetation. Elevation and slope are large contributing factors to species placement within natural landscapes.

3 Soils

What are soils?

Soil is a natural surface layer that contains living matter and supports (or is capable of supporting) plants.

Soil is made up of inorganic (mineral) matter and organic matter (living and dead). The living matter in soil is not only plant roots, but also consists of many types of organisms, including microorganisms.

Organic matter consists of plant litter on the surface, and humus dispersed throughout the soil profile. Humus is a very important component of soil. Some humus comes from plant litter that mulches the soil surface but most of it comes from plant roots. Good levels of soil humus assist with the stability and productivity of soils. It has a major effect on soils retaining moisture, resisting erosion and provides many attachment sites for soil nutrients. Humus is rapidly destroyed by aeration after cultivation or erosion events and burning. Its formation is also dramatically affected by annual forms of agriculture and grazing practices which inhibit root growth of pastures. In many temperate areas it has been calculated that 20 to 40% of organic matter is lost after fifty years of farming.

The upper limit of the soil is air or shallow water, but it is more difficult to define soil's lower limit. The lower limit of the soil is seen as the lower limits of biological activity which, in general, is also the common rooting depth of native perennial plants. Nonsoil is below the soil and may be bedrock or any form of sediment devoid of biological activity. The main difference between nonsoil (dirt) and soil is living organisms.

Soils are classified according to their physical and chemical properties of the soil horizons evident in the soil profile. Soil types are primarily functions of the interactions of the processes of soil formation.

Soil profiles and horizons

A soil that develops on rock develops a soil profile. A **soil profile** is the vertical section of soil from the surface through to the parent or substrate material (the upper and lower limits of soil) allowing proper analysis of the soil's properties.

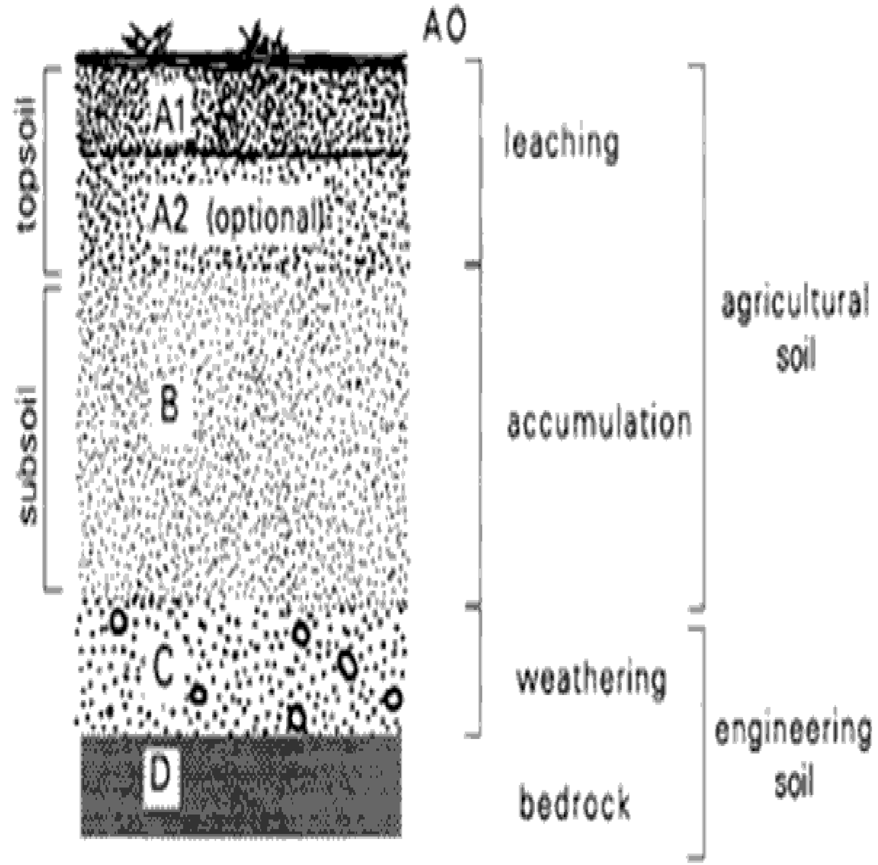
A soil profile is divided into layers known as horizons that develop over time. **Soil horizons** are distinctive horizontal layers that are different from each other by differences in physical and chemical composition, organic content, structure or a combination of those properties. The horizons of a soil profile form and grow by weathering and the addition of organic matter from decaying plants and plant roots. Soil horizons are developed by the interactions of soil forming factors.

Most soils have three distinct horizons, with the A and B horizons being the most important for plant growth:

- **A horizon** – also known as **topsoil**. This is where there is most soil life. Depending on the soil, the A horizon can be further divided into A1, A2 or Ao (organic).

- **B horizon** – sometimes called **subsoil**. This is where clays and materials washed down from the A horizon accumulate.
- **C horizon** – underlying weathering rock material.
- **D horizon** – bedrock. This is rock that has weathered to produce the soil you see above it (unless the soil has been deposited from elsewhere eg floodplains contain soil that has been carried downstream in water and then deposited as the flood recedes).

Figure 5.3.1.
Soil horizons and profiles.



The lower limits of biological activity are the lower limit of soil. In general, this is also the common rooting depth of native perennial plants.

Soil is classified according to the properties of each of the horizons, including colour, texture.

How do soils form?

Formation of soil

There are 2 main breakdown processes involved in the formation of soil:

- Mechanical breakdown, including the expansion and contraction from heating and cooling, and ice or salts getting into cracks.

- Chemical breakdown, which is principally an aerobic process, occurring mostly in the form of the reaction of water on rocks near the surface but also occurs from acidic breakdown.

Soil is continually being formed.

Soil continuously forms from the gradual breaking up of rocks through physical, chemical and biological processes known as weathering. The accumulation of material through the action of water, wind and gravity also contributes to soil formation. These processes can be very slow, taking many thousands of years. This makes soil a scarce commodity – one that should be used with care.

There are five main factors that interact and influence weathering processes to form soils. The interactions between these factors cause the infinite variety of soils across the surface of the Earth.

Parent materials

Soil minerals form the basis of soil. They are produced from rocks (parent material) through the processes of weathering and natural erosion. Water, wind, temperature change, gravity, chemical interaction, living organisms and pressure differences all help break down rocks. The types of parent materials and the conditions under which they break down will influence the physical and chemical properties of the soil formed.

The physical properties of soil influenced by parent material include:

- Soil texture – particle size is influenced by the parent material
- Soil structure

Parent material has a strong influence on the chemical properties of soil, particularly:

- Soil fertility – the minerals that make up the parent material are present in the resulting soil, and affect the minerals present and the resulting plant growth.

For example, soils formed from granite are often sandy and infertile. On the other hand, basalt under moist conditions breaks down to form fertile, clay soils. Parent materials also influence other soil characteristics such as particle size and other structural characteristics.

Organisms (biological activity)

Soil formation is influenced by organisms such as plants, micro-organisms such as bacteria or fungi, burrowing insects, animals and humans. As soil forms, plants being to grow in it; they mature, die and regrow. Their leaves and roots are added to the soil. Animals eat plants; their wastes and eventually their bodies are added to the soil. This begins to change the soil. Bacteria, fungi, worms and other burrowers break down plant litter and animal wastes and remains, to eventually become organic matter. Organic matter adds a darker, nutrient rich surface layer to the soil – the topsoil. Organisms also help to develop good soil structure.

Climate

Climate (rainfall, temperature and wind) influences the rate of weathering and also affects the amount to plant growth. Temperature affects the rate of weathering and organic decomposition. With a colder and drier climate, these processes can be slow, but with heat and moisture they are relatively rapid. Rainfall dissolves some of the soil materials and holds others in suspension. The water carries these materials down through the soil. This is known as **leaching**. Over time this process can changes the soil, making it less fertile.

Topography

The shape, length and grade of slope affects how well the land is drained, aspect determines the type of vegetation on a particular slope and the amount of rainfall received. These factors cause variation in the type of soils formed.

Time

The length of time that soil materials haven weathered influences the properties of the soil. As time passes minerals weathered from rocks are further weathered to form materials such as clays and oxides.

The different types of soils

Soils are classified according to their properties, such as **colour**, **texture** and **structure**. Soil type is determined on the nature of these properties and the distinctions between soil horizons.

Soil colour

Colour is the most obvious property of a soil. Colour can be an indication of the chemical and physical properties of the soil, which influences plant growth and appropriate land use. In some areas the soil colour may be influenced by the underlying parent material but generally it is a property generated by the processes of soil formation;

- **Black** – indicating the presence of abundant organic matter (humus);
- **Red**, **yellow** and **brown** – indicating the presence of iron oxides and low humus;
- **Grey** to **white** – indicating silicates and salts in a dry climate; and
- **Blue**, **grey** and **green** – in humid climates due to reduced iron in poorly drained soils.

So that soil colour description is consistent and objective in soil classification, books of standard colours (known as Munsell) have been adapted to the needs of soil science. Using these books, users can express soil colour as a letter-numeral code, indicating the three measurable variables that determine colour;

- **Hue** – the dominant colour of the pure spectrum;
- **Value** – the degree of darkness or lightness of the colour; and
- **Chroma** – the purity or strength of the colour.

Soil Texture

There are established size limits and names for the various grades of mineral particles in soils. There are three basic categories:

- **Sand** (0.05 – 2.0mm);
- **Silt** (0.002 – 0.05mm); and
- **Clay** (finer than 0.002mm).

There are also larger particles present in soil samples, namely pebbles (2-64mm), cobbles (64-256mm) and boulders (larger than 256mm).

Table 5.3.1
Grade sizes of sediment particles (adapted from Strahler and Strahler 1999).

Grade name		Diameter limits
Boulders		Larger than 256mm
Cobbles		256 mm
Pebbles		64 mm
Sand	Very coarse	2.0 mm
	Coarse	1.0 mm
	Medium	0.5mm
	Fine	0.25mm
	Very fine	0.1mm
Silt		0.05
Clay	Noncolloidal	0.002mm (2 microns)
	Colloidal	0.01 microns Below 0.01 microns

The larger grades of particles, such as sand, pebbles and cobbles, are often well rounded because of the slow abrasion that occurs that during transport by wind or water. Silt grains and coarse grades of clay are usually highly angular and appear under a microscope like crushed glass. Finer clay particles (colloidal size) typically exist in the form of thin scales and plates.

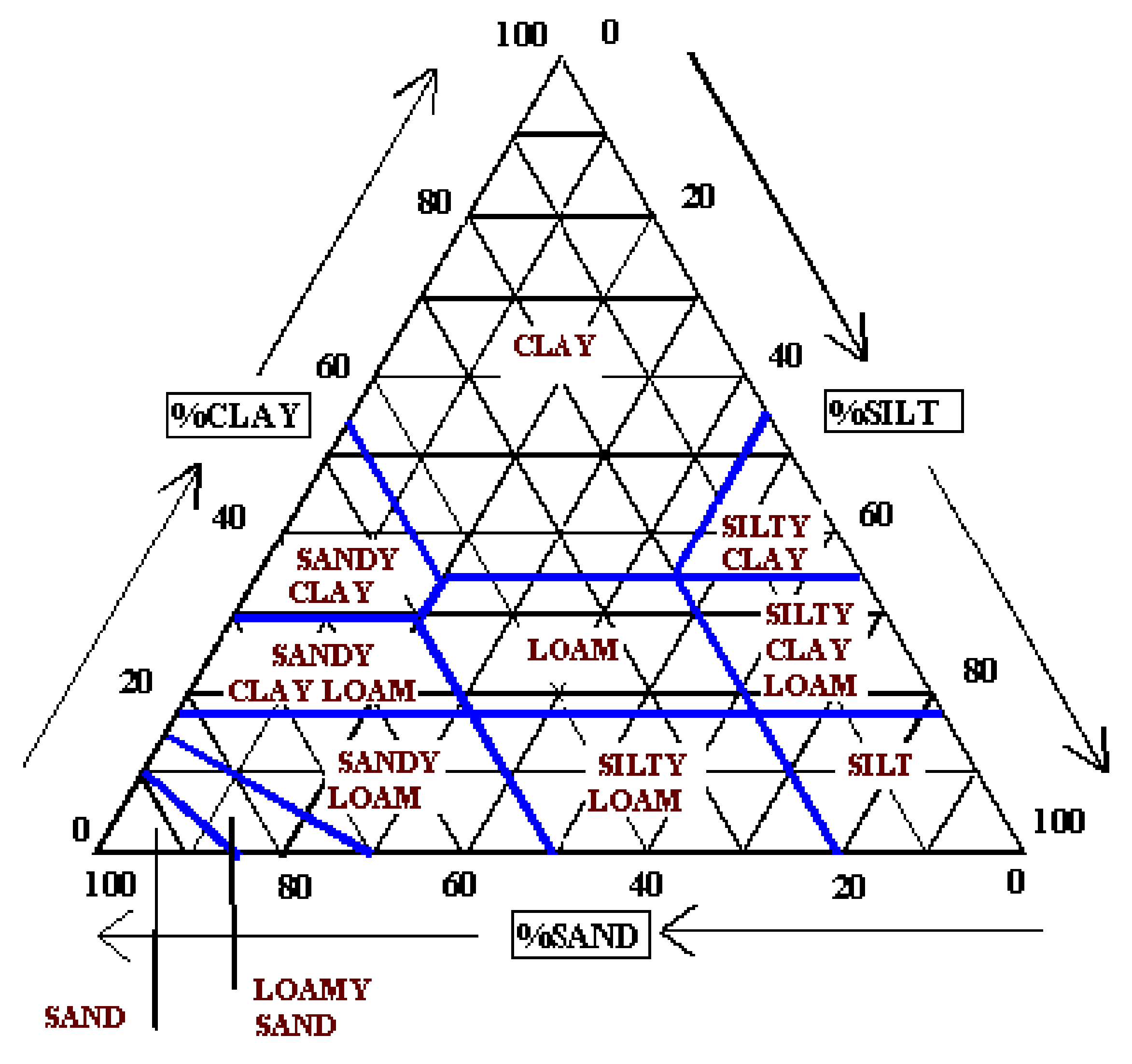
There are 2 grades of clay particles, according to size. Those finer than 0.01 micron are classed as **colloids**. One property of colloids is their ability to remain suspended in water indefinitely (ie they never settle to the bottom) following dispersion (separation from one another). Such a suspension is clouded or murky.

Decreasing particle size is accompanied by an increase in the surface area of particles contained within a given volume (known as the **surface area to volume ratio**). Particles of a colloidal size have a relatively large surface area. This surface area to volume ratio is important because water and nutrients are held on soil particle surfaces.

Soil texture classes are based on the varying proportions of sand, silt and clay present in a soil, expressed as percentages. The amount of each particle size in a soil is known as **particle size distribution**.

The standard system (US Department of Agriculture) of soil texture classes is shown in the triangular diagram, simultaneously indicating the percentages of all three components for each class. The triangle's corners represent 100% of each of the three particle grades – sand, silt or clay. **Loam** is a mixture of soil particle sizes in which there are equal quantities of the three particle grades and therefore appears in the centre of the triangle.

Figure 5. ..
Soil-texture classes, shown in areas bounded by heavy lines; the corners represent 100% of each of the three particle grades (Source Lindsell 2000).



The typical compositions of five particular soil texture classes are indicated further in the following table.

Table 5.3.2
Typical compositions of five soil-texture classes (adapted from Strahler and Strahler 1999).

Soil texture class	Dominant soil grade	Sand	Clay	Silt
Sandy Loam	Sand	65%	15%	20%
Clay Loam	Equal mixture of 3 grades	33%	33%	33%
Loam	Sand and silt in equal proportions	40%	18%	42%
Silty Clay	Clay and silt in equal proportions	10%	45%	45%
Silt Loam	Silt	17%	13%	70%

Soil texture is an important physical property as it determines the water storage and drainage properties of the soil, thus having a strong influence on plant growth. Sand may drain too quickly whilst the pore spaces in clay soil may be too difficult for drainage. In a soil with high clay and silt content root penetration may be difficult.

Soil structure

Soil structure is the arrangement of soil particles and the pore spaces between them, and also refers to the stability of that arrangement. It relates to the lumps or clusters (aggregates) of soil particles, which are separated by cracks and pores.

A soil with good structure has enough space between aggregates (pores) for water to move and be stored. By controlling water and air movement and root penetration, soil structure has a strong influence on plant growth. It is also an important physical property to agriculture because it influences how easily water will penetrate a dry soil, soil erosion susceptibility and the ease of cultivation.

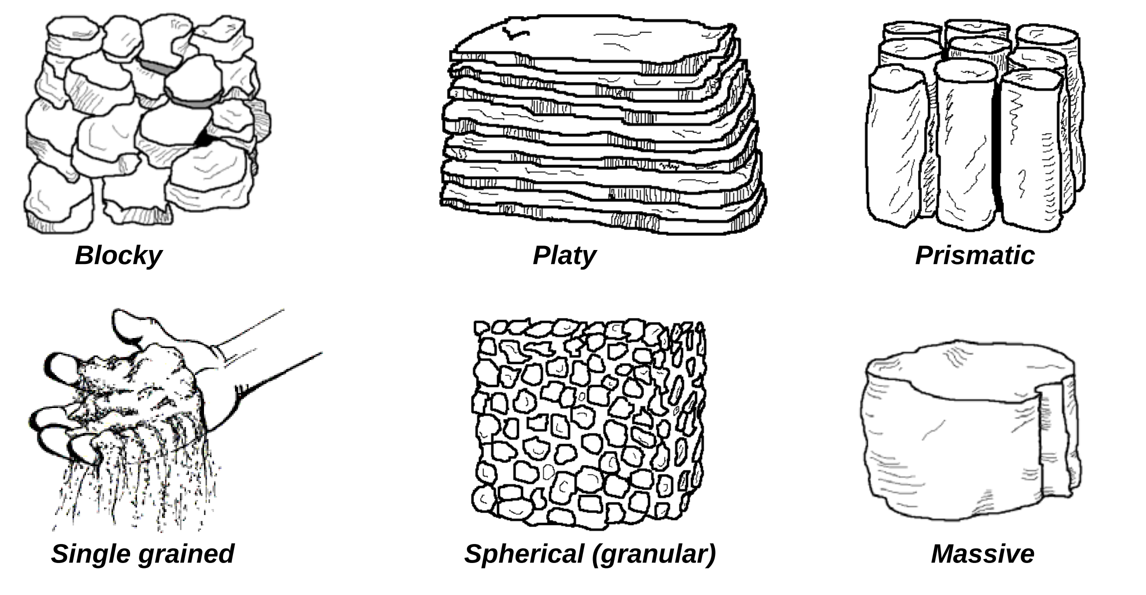
Organic matter plays an important role in the physical properties of soils, containing nutrients for plant growth but also helping to bind soil particles together to form aggregates, giving soil it's structure. Generally speaking, the higher the organic matter the better the soil structure.

Peds are the individual natural soil aggregates, whilst **clods** are the aggregates caused by breakage during cultivation. Characteristics of the shape, size and durability of peds are used to describe soil structure.

The main forms (shape and size) of soil structure are;

- **Blocky**: angular peds, usually 1.5 – 5cm in diameter, with flattened surfaces that fit the surfaces of adjacent peds;
- **Platy**: consisting of thin flat pieces (plates) in a horizontal position;
- **Prismatic**: peds are formed into vertical columns, often flat-sided, which may be 0.5 to 10cm across, usually found in lower soil horizons;
- **Single Grained**: soil is broken into particles that don't stick together, loose consistency, commonly found in sandy soils.
- **Spherical** (or **granular**): resembles biscuit crumbs, usually less than 0.5cm in diameter, consisting of peds that are almost rounded in outline with surfaces that don't fit those of adjacent peds; and
- **Massive**: the soil has no visible structure, appearing in very large clods that are difficult to break apart.

Figure 5.
Basic Soil Structures (adapted from Soil Science Education 2003)



The sizes of the peds (fine, medium, coarse) and their degree of durability (weak, strong) are also used to describe soil structure. The ability of a soil to maintain it's structural forms is known as its **structural stability**. Peds that resist remoulding (resilient) and soils that resist slaking (breaking up when wet) have high structural stability.

A soil with both low structural stability and low structural resiliency is a silty or fine-sandy topsoil, low in organic matter. It is degraded easily – even by raindrops – to form a hard-set layer.

Soil Classification

The soil profile is the entity classified using the **Great Soil Group** classification system (Stace *et al* 1968) or any other system such as that presented by Isbell (1996) known as the **Australian Soil Classification**.

Geology and Soil distribution

Geological zones can determine soil distribution as parent material plays the largest part in soil formation by providing base content, relative sodium content and crystal/particle size of the rocks. The rich soils the area is known for are due largely to the complexity of its formation, particularly its volcanic activity.

Soils

Alluvial Soils

These soils have not undergone much soil forming process, except for the development of A1 horizons, and they are known as 'juvenile soils. They are found in many of the soil landscapes, commonly occurring in low-lying areas such as creek or river valleys, floodplains, flats and drainage depressions. They originate from the erosion of hills (colluvial) or are moved about by water (alluvial). They basically consist of soils and parent materials from either upstream or areas adjacent to streams or rivers. These soils can be well drained and provide few physical boundaries to plant growth. They can be used intensively when irrigated and generally are used for cropping but, because of their location, these soils are susceptible to flooding and stream bank erosion. Examples of where these soils are found in the Central Tablelands Landcare district include in the lower areas of the landscape near Cudal, Manildra and close to the Macquarie River near Bathurst.

Alpine Humus Soils

Alpine Humus soils consist of organic matter and don't usually have a parent rock. They are found on high slopes (higher than 1 100m a.s.l.) of trachyte and basalt, and are shallow highly friable coloured sandy loams. As a result of the high organic content the surfaces of these soils often have a springy feel. These soils in the Central Tablelands Landcare district are restricted to the Mount Canobolas area and are dominated by snow gum (*E. pauciflora*) forest.

Brown Cracking Clays

Brown Cracking Clays range from light to heavy clays and are associated with rock outcrops in our area. It's a highly fertile, stable soil though it can become hard setting. It is commonly used for improved pastures. In this district they are found only around Byng and are made up of andesite alluvium.

Chocolate Soils

These soils are similar to brown cracking clays in that they are highly fertile and very stable. They also accumulate organic matter because of the area's cool climate. Grazing on improved pasture is practised on this soil. Examples of where these soils are found in the Central Tablelands Landcare district include midslope areas south of Oberon, Mt David and Truscott Flat.

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Earthy Sands

These soils are typically found on hillsides and have a uniform brown to reddish brown profile. They have a low fertility and high permeability. Examples of where these soils are found in the Central Tablelands Landcare district include the low rolling hills south and east of Orange around Panuara.

Euchrozems

Euchrozems are usually deep gradational soils in mid to upper slope locations. Their pH is neutral and they occur in dry areas on well drained slopes though there are some exceptions. They can be high in fertility and are used mainly for grazing though there is some wheat cropping in the western part of the CTLA. Dams built on or using this soil will leak. Examples of where these soils are located in the Central Tablelands district include the undulating low hills east of Molong, near Amaroo, around Cargo, Manildra and Cudal.

Krasnozems

Krasnozems are found in high rainfall areas on basalt hillsides. They intergrade with red earths and red and yellow podsolic soils in our area. They will fix nitrogen when added as fertiliser although they can become acidic. They are used for a variety of things such as orchards, pastures, and pine plantations. Like Euchrozems, dams built on this soil will leak. Examples of where these soils are located in the Central Tablelands district include lower slopes of Mt Caobolas, around Spring Hill, on the upper slopes south of Oberon, on undulating rises between Edith and Ginkin, small areas south of Trunkey and rolling low hills south of Carcoar and near Burnt Yards.

Non-calic Brown Soils
Non-calic Brown Soils occur where rainfall is less than 750mm/year on hillsides. They have a number of different parent materials. Their limitations include low fertility, acidification, salinity, toxicity, high erodability under cultivation and a hard setting surface. Typically used for grazing though under good management cereal and rapeseed cropping is maintained in the west of the region. Examples of where these soils are located in the Central Tablelands district include around Manildra, Molong, on the lower slopes around Borenore, Lyndhurst and Bowen Park.

Red Earths
Red earths are found on well-drained slopes and crests and have a variety of parent materials. These soils are mainly used for native and improved pastures. They are stable soils especially under improved pasture though they tend to become acidic quickly. Examples of where these soils are located in the Central Tablelands district include areas high in the landscape west of Lithgow, around Oberon and around Vulcan near Lyndhurst.

Red Podzolic Soils
These soils occur on well drained upper to midslopes on a variety of parent materials. They have low to moderate fertility and respond well to pasture improvement. They are more stable than other podzolic soils and support a broad range of vegetation. Red podzolic soils are widespread in the south-western Central Tablelands Landcare area. Examples of where these soils are located in the Central Tablelands district include near Burraga, Trunkey, Mullion Creek and Cargo.

Red Solodic
Red solodic soils are usually found mid to lower slopes. They are chemically infertile due to chemical leaching and are strongly differentiated between the A and B horizons. They are used for grazing native pastures and have a high gully erosion risk. Examples of where these soils are located in the Central Tablelands district include flowlines around Lyndhurst.

Shallow soils (Lithosols)
The lithosols in our area behave a bit differently than those described in the Great Soils Group system (Stace *et al*., 1968). Rather than being strictly a uniform, shallow soil overlying rock, they seem to show some development in the subsoils. They usually intergrade with soils in the surrounding landscape, are found on steep slopes and support a broad range of native vegetation. Examples of where these soils are located in the Central Tablelands district include tops of many ridges which are usually gravely.

Siliceous Sands
Siliceous sands form on granite hillcrests and slopes. They are very permeable and chemically infertile though some support improved pasture with heavy fertiliser application. They can also be highly erodible due to slope, poor structure and low fertility. Examples of where these soils are located in the Central Tablelands district include areas north of Manildra.

Soloths
These soils occur on lower slopes and drainage depressions (they are thus related to topography). They are quite acidic, have a low chemical fertility and can be highly erodible, especially gully erosion. Improved pasture is the most common use of this soil. Soloths are the dominant soil in the north-central part of the Central Tablelands Landcare district and are largely restricted to the Hill End Trough geological zone. Examples of where these soils are located in the Central Tablelands district include around Molong, Bell River and through to Hill End

Terra Rossa Soils
Terra Rossa occur on well-drained limestone. They are quite stable though shallow, usually resting on parent rock. They are normally used for grazing simply because they are found on steep, upper slopes with rocky outcrops making more intensive use difficult. Examples of where these soils are located in the Central Tablelands district include around Molong, Cargo and Cudal and other places where limestone is found.

Yellow Earths
Yellow earths are similar to red earths except in colour. They only occur in our Landcare area in the Vulcan state park. They have a low chemical fertility and are typically used for native and improved pastures except in the Oberon area where they are used for pine plantations or have not been cleared.

Yellow Podzodic Soils
These soils are found mostly midslope in the south of the Landcare area. They have low fertility and are mainly used for grazing. They support a wide range of native vegetation along with some pine plantations around Mayfield. Examples of where these soils are located in the Central Tablelands district include areas around Trunkey, Burraga, Abercrombie, Oberon and Lyndhurst.

Black Earths
These soils are black and weakly differentiated, with textures ranging from light to heavy clays with increasing soil profile depth. They are deep (up to 1.5m) with strong structure and have alkaline soil reaction trends. Black earths are suitable for cultivation on the flats, although problems can occur when they are wet. A high capacity for water storage must be balanced against the possibility of erosion problems when high runoff from adjacent slopes. Black earths occur on the alluvial flats and the lower slopes of the area surround Campbells River, their occurrence appears to be related to the serpentine intrusions that have been exposed on adjacent slopes.

Our Soil Landscapes

Soil Landscapes is a term used to describe areas of land that have recognisable patterns. These patterns appear because of similar combinations of topography, soils and geological or geomorphological materials. Each soil landscape is also influenced by vegetation, climate and drainage regimes.

Our Soil Landscapes are included in the map section of this toolkit. From it you can see what Soil Landscapes exist in your area and can see what other areas may share your Soil Landscape. There are over 40 Soil Landscape areas in the Central Tablelands.

Many natural resource issues that require more attuned management and treatment will often (but not always) fall within the same Soil Landscape area. This information is useful to see if the issues you want to tackle are common throughout a Soil Landscape area. If so – you and your group are in a much better situation to explain the extent of the issue to those in your district who do not know.

For people who would like to research this more all Soil Landscapes, their characteristics and location are available in the “Soil Landscapes of the Bathurst 1:250 000 sheet” Kovack, Lawrie and Murphy 1990. These books are located in all of the CMA and DNR offices in the Central Tablelands district.

Two of the authors are still employed locally. Brian Murphy works in the Cowra Department of Natural Resources office and John Lawrie works for the Central West CMA in Wellington.

4 Land Classes

Using our land

Land use is based on the different qualities of the land, including slope, soil type,

Land capability is what the land is capability of producing without degradation (such as erosion). **"Land capability describes the ability of land to sustain a type of land use without causing it permanent damage. If land is used beyond its capability it will lose production and degrade."**

Land used for agriculture is classified into classes to determine the most appropriate land uses, based on slope, vegetation, soil type, climate, social characteristics and limitations to production.

The main uses of agricultural land in NSW are;

- Dryland agriculture,
- Irrigated agriculture,
- Intensive animal production (i.e. feedlots),
- Horticulture, and
- Mixed farming.

Limitations to agricultural production that can influence land capability include:

- Effective soil depth (eg. less than 1 metre)
- Light soil texture (eg. light texture is prone to wind erosion)
- Very heavy soil texture (eg. heavy clay is very hard to work)
- Water logging (e.g. poor natural drainage)
- Soil chemistry (eg. pH<5.5 or salinity > 1800 ppm)
- Soil structure (eg. tendency to form crusts and pans)
- Impediments to cultivation (eg. boulders, crab holes, gravel patches)
- Flooding (eg. once in 5 year frequency)
- Land slope (eg. greater than 3% on sand and 5% on clay)

Land classes

Agricultural land is classed according to its capability. Different states use slightly different systems, all with the same principle of classifying land according to capability and limitations to production. Land classification systems are used for property planning.

Land is classed according to slope and soil type, hydrologic variables etc., and limitations to production, and each class relates to the most appropriate land use for that particular class, also known as the particular **land capability**. It has become an important tool in rural resource planning, such as property management planning (also known as whole farm planning).

There are many systems used in the classification of agricultural land. One system is the Eight Class System used by Farming for the Future in the 1990s and the

NSW Department of Land and Water Conservation (NSW Agriculture *et al.* 1999). The following table outlines the Eight Class land classification system.

Table 5.4.1 Land Classes (Adapted from "Soils Their Properties and Management" Charman & Murphy *et al*., 2007)

Class	Brief description	Examples
	SUITABLE FOR CROPPING	
I	Wide variety of uses. No special soil conservation works or practices necessary.	Vegetables, fruit, grain and fodder crops.
2	Can be cultivated but strip cropping, conservation tillage and adequate crop rotations are necessary.	Grain and fodder crops
3	Structural conservation works such as graded banks and waterways are necessary. Land that is cultivated requires all the conservation practices of class 2.	Grain and fodder crops.
	SUITABLE MAINLY FOR GRAZING	
4	Suitable mostly for grazing practices and can be cultivated occasionally using conservation practices such as stock control, application of fertiliser, minimal cultivation for the establishment or re-establishment of permanent pasture. Maintenance of good ground cover is paramount.	Grazing with pasture improvement.
5	Similar to class 4 and includes soil conservation works such as diversion banks and contour ripping. Maintenance of good ground cover is also paramount.	Grazing with occasional pasture improvement
	SUITABLE FOR GRAZING	
6	Not capable of cultivation. It is a lower production grazing area. Requires soil conservation practices such as limitation of stock, broadcasting of seed and fertiliser, promotion of native pasture regeneration, destruction of vermin. It may require some structural works. Maintenance of good ground cover is paramount.	Occasional grazing
	SUITABLE FOR TREE COVER	
7	This land class is best protected by the natural ecosystem communities of the area – such as native grasses, shrubs and trees. They provide valuable ecosystem services such as biodiversity which help filter water and provide areas that rebalance the concentration of agriculture and urban areas.	Provide habitat and biodiversity for native animals and plants.
	NOT SUITABLE FOR AGRICULTURE	
8	Cliffs, lakes or swamps and other lands where access is an issue and they provide ecosystem services such as those in class 7.	Provide habitat and biodiversity.

Salinity

Salinity is a measure of the *total* soluble salts in the soil, not just sodium chloride.

"Salinity development is a function of the interrelationship between certain biophysical features such as landuse, geological and soil characteristics, hydraulic loading and landscape features, that result in an observable hydrological imbalance. The salinity hazard of an area is exemplified by the activities, attitudes and financial situations of the people living within the area. Complex and widespread salinity throughout the Central West is the result of the combination of these two factors.”

“Salinity is regarded as one of the greatest environmental threats facing the Central West of NSW. Recently, a report to e the Prime Minister’s Science, Engineering and Innovation Council (PMSEIC 1999) suggested that by the year 2100, the amount of salinised land in NSW will rise from the current estimates of 120 000 hectares to an estimated 7.5 million hectares. The Murray Daring Basin commission Ministerial Council’s (MDBCMC), released Salinity Audit predicts that the Macquarie, Bogan and Castlereagh catchments will have some the highest electrical conductivity (EC) and salt load levels within he basin. Many of these predicted levels will exceed the World Health Organisation’s (WHO) standards for drinking water and potentially threaten ecological systems.
“The Central West Catchment Management Committee (CWCMC) has recognised the importance of salinity within this catchment for many years. This knowledge has been supported by a number of key government agencies who have committed ongoing resources to the areas of salinity research, investigation and extension. The affects of salinity are also being felt, both financially and environmentally by the general community.”

“Although salinisation is a natural process, increased rates of salinity development result from a hydrological imbalance in the landscape. This imbalance is observed in increasing stream EC and salt load levels, growing areas of saline affected land and infrastructure decline in urban areas throughout the catchment. Scientifically, this imbalance is reported in MDBCMC Salinity Audit results, the Department of Land and Water Conservation salinity known sites mapping and the numerous hydrogeological investigations that have been completed within the catchment.

“Geology is only one in a large number of factors that can lead to salinisation. The source potential risk indicates the capacity of the rock to produce and/or concentrate salts contributing to salinisation processes. This potential relates to a number of rock properties, including:

- Whether the sediments were laid down in marine or freshwater conditions
- The rock porosity
- The degree of metamorphism
- The grainsize of igneous rocks
- The geochemistry of the rock types.

In general, weathering of coarse grained or porphyritic igneous rocks with a granite composition has a higher potential of releasing salt forming ions into the groundwater than finer grained igneous rocks. Metamorphism leads to the formation of new minerals that also water releasing salt forming ions. Coarse-grained sediments are generally quite porous and permeable and hence any salt they contain is relatively easily leached out. If these are old rocks, there is little potential salinity contribution, as salt would have been leached out them long before any anthropogenic influences were placed on the land. Fine-grained sediments, especially those having a marine origin, are much less permeable and can store salts for a very long periods of time. These rocks have been given a high potential risk rating. Alluvial/colluvial unconsolidated sediments were assigned a moderate potential risk rating due to their location in lower parts of the landscape where most natural discharge occurs. “

5 Conclusions

Our entire physical landscape, including topography, elevation and soils is determined in the first instance by the local geological activity. Climate and human activities also influence the production and land use that can be undertaken sustainably.

6 References and Further Information

Sources used

The following are sources used in the writing of the Land section of the Central Tablelands Landcare Toolkit:

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Branagan, D.F., and Packham, G.H. (1970). Field geology of New South Wales. 2nd Edition. Science Press, Sydney.

Charman, E. V. and Murphy, B. W. (2007) Soils their property and management. 3rd Edition. Oxford University Press, Australia.

Earth Science Australia. On-line national curriculum science syllabus certificate course 'The Earth and Beyond'. http://earthsci.org/teacher/basicgeol/

Humphries, E. (2000). Salinity risk assessment of the Central West Catchment (Macquarie, Castlereagh and Bogan Rivers). A joint initiative of the Central West Catchment Management Committee and the Department of Land and Water Conservation (Central West Region).

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Whittow, J. (1984). The Penguin Dictionary of Physical Geography. Penguin, London.

Where to find more information

The following references and website addresses will provide more detail about the topics outlined in the Land Section of this Toolkit:

Geology

Earth Science Australia provides good information about the topics outlined in this section:

http://earthsci.org/teacher/basicgeol/

The following very interesting site is produced by Australian volcanologists, with good information about Australian and international volcanoes:

http://www.volcanolive.com

Soils

For more detailed information about soil profiles see:

http://www.agric.nsw.gov.au/reader/efarm-soils/what-is-a-soil-profile.htm

The Australian Soil Classification (Isbell) is available online:

http://www.clw.csiro.au/aclep/asc_re_on_line/soilhome.htm

The CSIRO has published a poster of Australian soils, which is available for purchase from the CSIRO or online (2.3MB):

http://www.clw.csiro.au/aclep/asc/asc.htm#poster

“Lachlan Soil Management Guide” – a document funded by the Natural Heritage Trust. Copies can be found at the Lachlan CMA offices and the Cowra Department of Primary Industries office.

Land Classes and Property Planning

There are many sources of information of interest for classing land and for assisting with developing property plans. Keep in mind that land classification systems vary between Australian states and territories and internationally, but they all have the same principles. Take a look at the following websites or books for more information about land classification and property planing:

http://www.longerenong.unimelb.edu.au/cats/landman.htm

http://www.nswfarmers.org.au/_data/page/1507/landtenure_6.pdf

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