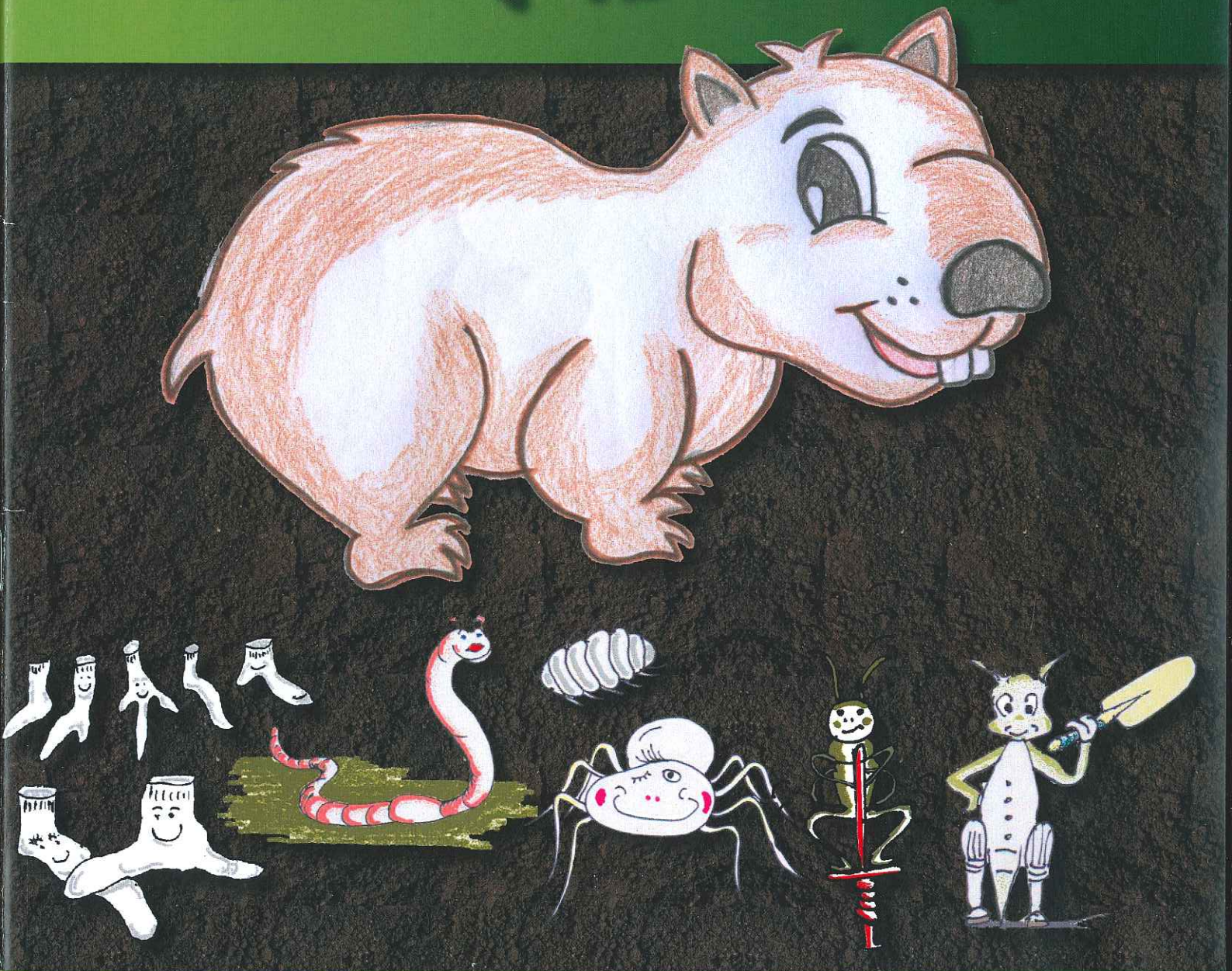
NSW GOVERNMENT Local Land Services

CARING FOR OUR COUNTRY

SOIL EXPLORER WORKBOOK



LEARN ABOUT THE WONDERS OF SOIL WITH WAZZA THE WOMBAT AND HIS FRIENDS...

TABLE OF CONTENTS

ABOUT SOIL EXPLORER

Soil Explorer has been developed primarily for Stage Three Primary School Students to build their understanding of soil science. Despite this focus it is still a useful resource for soil and land management extension and education for any age group.

Technical and Editorial contributors to Soil Explorer are Alan Welch and Ian Packer, who between them have several decades worth of experience in working with soil, learning about soil and helping others to learn about soil.

Without their wonderful insight and wisdom, Soil Explorer would never have been.

Wazza Wombat and Soil Characters by Alan Welch, additional graphics by Lisa Starr. Thanks also to Dominic Nowlan and Neroli Brennan for additional soils photos.

Co-ordination and Editing by Nina Hooper of Local Land Services and Layout and Design by Lisa Starr of Starr Designs.

March 2014.

MEET WAZZA

G'day. My name is Wazza. I am a Wombat. I can teach you lots about dirt because I live in a hole in the dirt. It is a good place to live because it is safe and cool. I like safe and cool.

SOIL does a wonderful job for people. It does a wonderful job for all living things on the land. SOIL grows most of the plants we eat. It grows beans, carrots and potatoes. SOIL grows wheat that we use to make bread. SOIL grows grass to feed cows so we can have milk and meat. SOIL grows cotton so we can make our clothes. SOIL grows trees with apples so we can have a nice juicy one after school.

SOIL holds up our buildings. That is a very heavy job! It even makes the bricks we use to build our house. It makes the dirt house where wombats live too.

SOIL covers up our garbage when it goes to the tip. It helps make our roads so we can go to the beach for a holiday. SOIL even makes the beach.

SOIL is really the Earth's most precious resource. If there was no SOIL, nothing could live on the land. We need tiny and big creatures on the land to help make new SOIL from the rocks.

G'day!
My name is Wazza the Wombat. You are about to dive headfirst into the exciting world of soil!

When we care for the environment, we need to care for the SOIL too!

In 1906, two famous men (Farrer and Sutton) said they would like to cover the land with a blanket of SOIL, with lots of organic matter. This would let rain soak in better. It would stop the SOIL from cracking, and drying out too much. These men knew it is really important to keep water in the SOIL to grow food for people .....and wombats!

All the animals need SOIL to grow their food. They need SOIL to grow trees so there are safe and secret places to live.

Big animals that you can see, like earthworms, bettongs, wombats and bilbies, need SOIL to dig the holes they live in.

Then there are tiny animals that you need a microscope to see, like SOIL microbes and bacteria. They need SOIL to keep them cool and moist so they do not dry out and die.

LET'S START AT THE BEGINNING
Where do SOILs come from?

Everywhere in the world, you need five main things to make SOIL.

1. The **parent materials** – these are the rocks or other things the SOIL is made from
2. The **weather** at the place where the SOIL is made. SOIL made in hot wet places is different to SOIL from dry places or cool places
3. The **position in the land** where the SOIL is made.
4. The **life in the SOIL** and what it does.
5. **Time** – old SOILs are different to new ones.

THEY ARE ALL DIFFERENT

These **five** things control the **weathering** that breaks up rocks into SOIL. They also control where clay, sand and silt particles move to in the SOIL.

When the **five** things all happen together, they make SOILS that are **special** to a particular spot in the land. No two SOILS are ever exactly the same!

No two SOILS are really ever the same!

1. PARENT MATERIAL

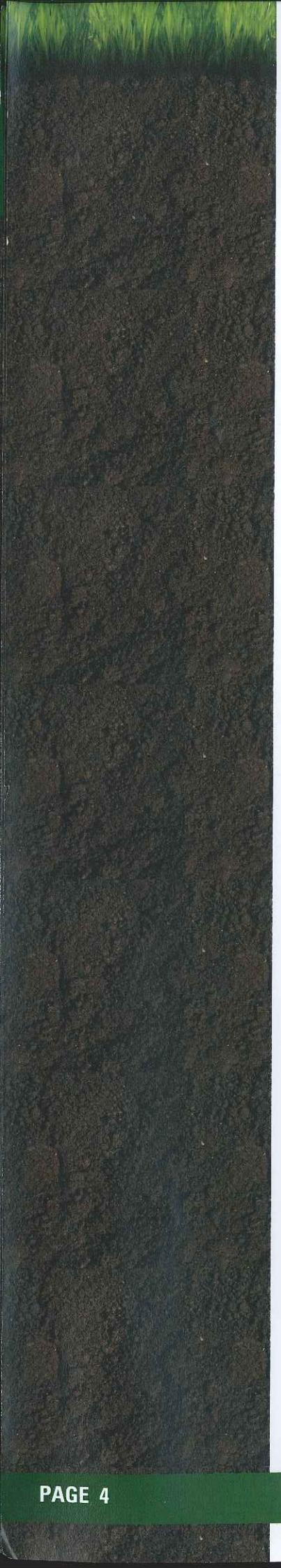
New children need a Mum and Dad to be their parents. New SOIL needs **parent material** for it to be made. In Australia, parent material is mostly one of the following types.

- **Local rock** can make SOILS.
- **Colluvial** material washed down a slope by water can make the SOILS.
- **Alluvial** material deposited by flowing rivers and creeks can make the SOILS.
- **Aeolian** materials deposited by wind can make SOILS.
- In other countries, glaciers scrape up and move rock material to make SOILS.
- **Landfill** and mine waste left behind by people sometimes makes SOIL.

2. WEATHERING

Hot and cold, or wet and dry conditions weather the rocks. They cause shrinking, swelling and cracking into smaller pieces. Wind, water and ice can lead to **physical weathering**. Acid from the rocks or rain can also change minerals in the rock to make new SOIL material. This is **chemical weathering**. The minerals and chemicals in the rock control how quickly the SOIL forms. They control the type of SOIL it will be. They also control the size of SOIL particles when the rock breaks down.

New SOIL is always being made. The weather is always changing SOIL slowly. Even when SOIL is washed or blown away, it settles in a new place. In the new place, it becomes part of the parent material for a new SOIL.



3. POSITION IN THE LAND (CALLED TERRAIN)

SOIL made on top of a hill is different to SOIL made in the bottom of a valley, or half way up a hill. SOIL made in a flat place is different to SOIL made in a steep place. SOIL formed on hilltops has materials and minerals washed away from it. It has brighter colours. It is not as deep and is usually drier. SOIL made on a hilltop may have only large harder to move materials left behind such as rocks.

SOIL in a valley floor has material washed into it from the hilltops. It will be deeper, probably more fertile and wetter, but is not as brightly coloured.

4. LIFE IN THE SOIL

There are lots and lots of living things in the soil. If we could weigh all the sheep on a farm at Canowindra and then weigh all the soil bugs on the same farm- the bugs would be about four times heavier than the sheep. There are millions of them. There are big ones our eyes can see, like worms, termites and dung beetles. There are medium sized ones we can see with a hand lens, like mites. There are tiny ones we need a microscope to see, like protozoa and nematodes. There are other tiny living things too, like bacteria and fungi. They all have jobs to do to make the soil healthy and fertile. Later on we will talk more about the jobs they do to make healthy soil.

5. TIME

Time slowly changes all SOILS. Over time, lots of actions happen to make a SOIL.

Very old SOILS are less fertile as the weather has washed the chemicals and minerals from the SOIL. We call this **leaching**. When water or wind adds more material to the SOIL, we call this **deposition**.

When the weather is very wet, tiny air spaces in the SOIL fill with water. It squeezes all the air out. We call this water logging. It changes the way chemicals weather rocks and soils. Drainage happens when the water empties out of the air spaces again.

PARENT MATERIAL

WHAT KINDS OF PARENT MATERIAL ARE THERE?

Parent Materials are mainly rocks. There are four kinds of parent materials

- **Igneous Rocks** - Hot molten lava makes these rocks.

- **Sedimentary Rocks** - Water or wind moves weathered rock and soil pieces. When they stop moving they make sediment deposits. After a long time, when the sediments are rock hard, they become sedimentary rocks.

- **Metamorphic Rocks** - Heat and pressure changes buried rocks. They can change into metamorphic rock. Marble is a metamorphic rock made by heating limestone.

- **Loose surface materials** - These are younger than rocks and not as hard. They are mostly less than one hundred thousand years old. The three kinds of loose material are:
  - **alluvium**
  - **colluvium,** and
  - **wind- blown material.**

  Rivers and creeks deposit **alluvium** on floodplains (like Bland Creek near West Wyalong). **Colluvium** is material moved by gravity and water to the bottom of a slope. The red SOIL near Young (where the cherries grow), is **wind-blown material.**

HOW OLD ARE THE ROCKS?

Most SOILS in New South Wales come from rocks made in the last 550 Million years.

There are **three age groups** for rocks.

TRILOBITE

1

The **oldest age group** is rocks made from 550 to 250 million years ago. Geologists call this **Paleozoic** time. It means the rocks can have **early animal** fossils in them. The types of animals that were around in the Paleozoic were Trilobites and Armoured Fish.

ARMOURED FISH

2

The **middle age group** is rocks made 250 to 65 million years ago. It is called **Mesozoic** time. It means the rocks can have **middle animal** fossils. This time includes the Jurassic period when there were Dinosaurs, and when flowers bloomed for the first time.

TRICERATOPS

MUTTABURRASAURUS
QUEENSLAND

3

The **youngest age group** is rocks made between 65 million years ago and now. It is called **Cenozoic** time. It means the rocks can have recent animal fossils. During this time, there were giant wombats around, called Diprotodons. They were 3 to 4 metres long and 2 metres tall – whoppers! There were also Sabre - toothed tigers, mammoths and giant sloths.

DIPROTODON
REALLY BIG WOMBAT

ACTIVITY ONE 01

WHY NOT BECOME A ROCKHOUND AND START A ROCK COLLECTION?

Keep an eye out for interesting rocks in the garden, in the playground and in the paddock or the bush. When you are collecting make sure you think about the following safety tips from **www.rocksforkids.com**

- Never try to break a rock without wearing safety goggles. Breaking rocks takes practice. Have an experienced rockhound show you how with proper tools. Each rock has a different way of breaking.
- Do not use regular tools like hammers, chisels, woodworking chisels, axes etc. to break your rocks. They weren't designed for this, you will damage them and you will hurt yourself when the tool breaks.
- Wear gloves. Sometimes rocks can give you slivers and quartz is sharp enough to give you a nasty cut.
- Rocks are hard and often rough. They can scratch you as well as any furniture you put it on.
- Wash your hands thoroughly after handling rocks and before eating. Some minerals can make you sick.
- Don't wash your rocks in the sink at home. You could scratch the sink and the dirt could clog up your pipes – Mum and Dad won't be happy! Wash your rocks in a tub of water and dump the water on your garden outside.
- And most importantly be careful of spiders and snakes!!

Keep your rocks in a cardboard box. Make some notes on your collection. Which ones do you think would wear away quickly? Which ones would take longer – why? Look at your rocks with a magnifying glass – what do you see?

NOTES

HOW DOES PARENT MATERIAL AFFECT THE SOIL WE SEE EVERY DAY?

Parent Material affects the SOIL in several ways.

- SOIL chemical fertility - how well the SOIL can grow plants;
- The SOIL texture (or SOIL recipe) - how it feels when we make it into mud;
- SOIL structure - how stable and well arranged the SOIL particles and its spaces are;
- SOIL acidity – how acid the SOIL is
- SOIL sodicity – how well the SOIL resists damage by wetting and setting.
- Erosion risk – how easily SOIL blows away or washes away
- SOIL shrinking and swelling - when it absorbs or looses water.

Parent Material affects the SOIL in several ways.

Wendy Worm

"We are the ultimate soil scientists. We help get air into the soil - improving it's drainage and structure and help make good nutrients more available to plants."

WHAT ARE THE OTHER PARTS OF THE SOIL?

SOIL has many parts. SOIL has more than just dirt in it. SOIL is a living thing with 5 main parts:

1. **The "dirt"** or **solid** part made from parent material we have already talked about.
2. **Organic Matter** - rotted down parts of animals and plants that used to be alive
3. **Water** – in the spaces between the "dirt"
4. **Air** – in the spaces between the "dirt"
5. **Soil Organisms** – the many things living in the SOIL

Some of the living things are a bit like plants. Other ones are like animals. We can see the big ones with our eyes. We need a powerful microscope to see the tiny ones. People call some of them "germs". People cannot eat SOIL because some of germs in it might make them sick

WAZZA WOMBAT'S LIST OF THINGS THAT LIVE IN THE SOIL

TINY PLANT LIKE THINGS	BACTERIA FUNGI ACTINOMYCES ALGAE
TINY ANIMAL THINGS	PROTOZOA NEMATODES WORMS SPRINGTAILS
BIGGER ANIMAL THINGS	WORMS INSECTS ANTS SNAILS SPIDERS MITES CENTIPEDES MILLIPEDES AND WOMBATS sometimes)

The animals and plants that live in the SOIL are a bit like us. They need food, water, air and shelter to live healthy lives.

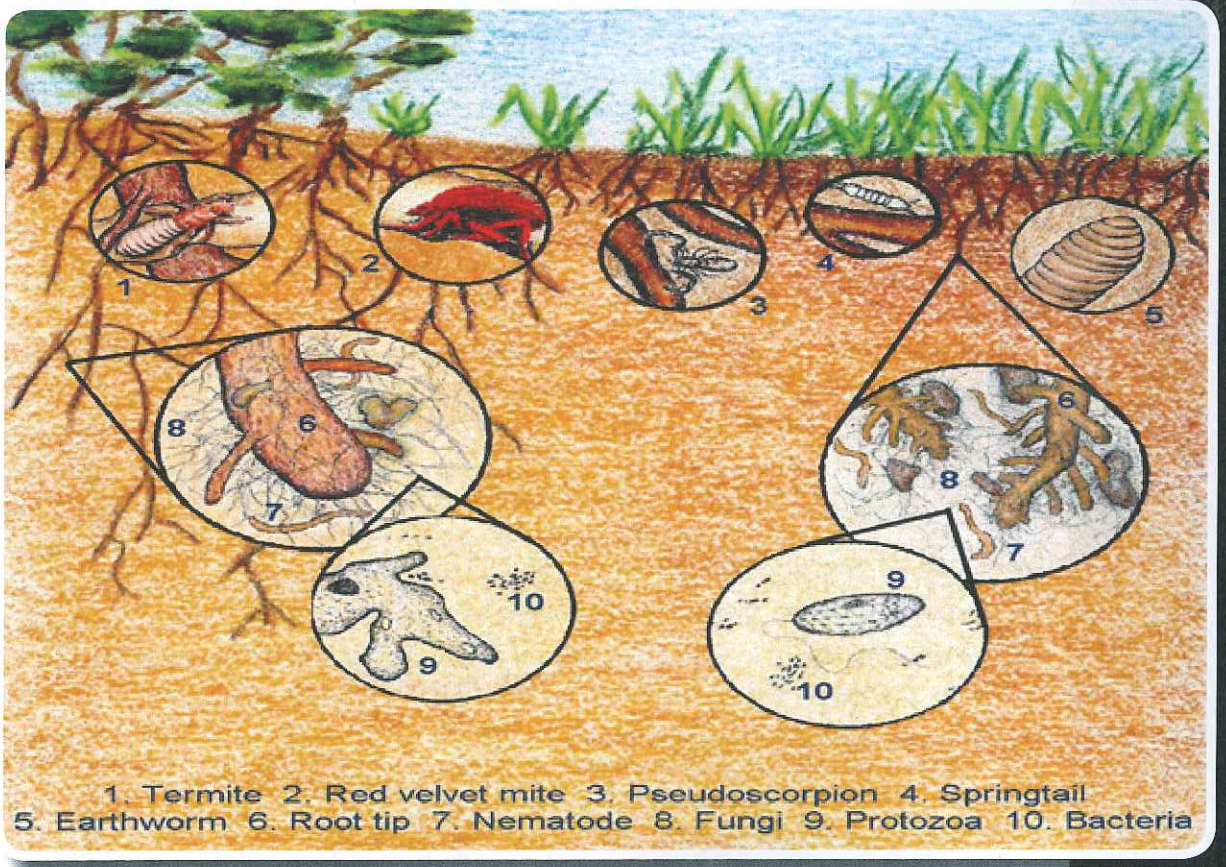
Healthy SOILS have all these.

- They have organic matter for food.
- They have water and air in the spaces between the dirt bits.
- They have plenty of spaces with safe shelter for the SOIL organisms.

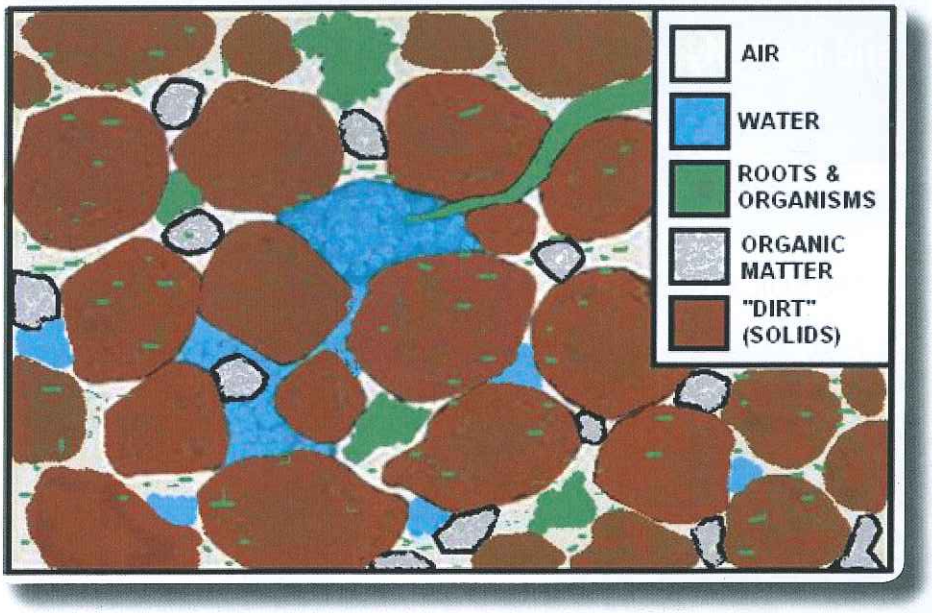
Plants need the SOIL to have "available water". This is water that plants can suck out with their roots. Plants need the SOIL to have more than 10% air as well

Wazza Wombat

A PICTURE OF SOME SOIL ORGANISMS



A PICTURE OF THE FIVE PARTS OF THE SOIL



SOIL HEALTH

People now are learning what SOIL needs to be healthy. However, people did not always know. Some people made mistakes with the SOIL. They caused damage to the SOIL health because they did not know.

Imagine if you were a SOIL organism and the following things happened to you. Wouldn't they be terrible for your health?

Imagine if you:

were cut in two with a giant sword;
OR – you were crushed to death in your house when the walls and roof fall in;
OR – you were trapped in a small space with no air;
OR – ran out of water;
OR – ran out of food;
OR – you died from being too hot or froze from being too cold.

All these things can happen to organisms in the SOIL.

- Cut in two with a giant sword – this is what people do with a plough.
- Crushed to death in your house when the walls and roof fall in – a sheep or a cow tramples the soil, or a tractor drives on top of it.
- Trapped in a small space with no air – all the SOIL pore-spaces and channels are blocked by ploughing or by tractors crushing the tunnels.
- Run out of water – rainwater cannot get into the SOIL as it has no holes or spaces in it for water to get into and be available for soil bugs. The water will just run away.
- Run out of food – all the surface cover, plant roots and organic matter are burnt, grazed or smashed up with a plough.
- Die from being too hot or freeze from being too cold – all the protective plant material has gone and the SOIL is bare. The SOIL does not have any cover.

SOIL bugs and organisms are no different to us. They all need the same things we need to live and multiply.

Wazza Wombat

Now we know this, let's be careful with the SOIL so our farming does not kill soil organisms. Without the SOIL organisms, there is no life in the SOIL. Plant and animal material, is not changed into SOIL organic matter. SOIL food runs out. Then plants and animals cannot grow properly. The SOIL is not healthy.

Now people are learning how to look after the SOIL organisms that keep the SOIL living and healthy. Soil organisms are the most important part of SOIL health.

SOIL BUGS, SOIL ORGANIC MATTER AND WHAT THE BUGS DO

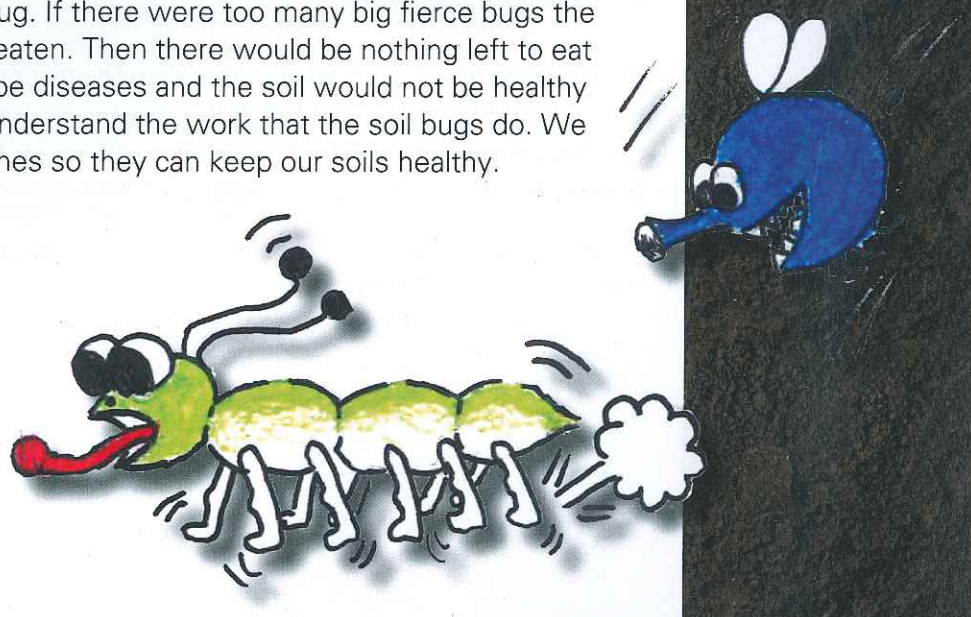
One of the most important jobs that Soil Bugs do is change organic matter into plant food.

CHANGING ORGANIC MATTER INTO PLANT FOOD NUTRIENTS

Organic Matter in the soil is like a jig saw puzzle for the plants. The picture on the puzzle has a delicious huge meal of organic matter for a plant. But the plant cannot eat the whole meal at once. It needs somebody to pull apart the huge meal into much smaller pieces. The nutrients in it need to be small enough for plants to absorb. This is a job for the soil bugs. The bigger bugs break down the bigger organic matter into pieces, the medium size ones make them smaller. The smallest bugs do most of the work. The smallest bugs are bacteria and fungi. They make tiny pieces of delicious nutrient that are easy for plants to absorb. The bugs even find tasty bits in the dirt part of the soil to sprinkle on it so the plants will be really happy.

Most of the soil bugs live and work in the "topsoil world" or top 10 cms of the soil. Most of them need air to work properly. Inside the "topsoil world" there are thousands of different bugs. When the soil is very healthy and all the bugs are working well, we call it a Soil Food Web. It works just like the jungle. Bugs eat organic matter. They also eat other bugs. The bigger fierce bugs eat smaller bugs. Smaller ones eat tiny ones. Some of the tiny ones can cause diseases which can kill bigger ones. Good tiny bugs eat bad tiny bugs if they try to make diseases.

For the "topsoil world" to work properly there needs to be just the right number of each kind of soil bug. If there were too many big fierce bugs the smaller ones would soon be eaten. Then there would be nothing left to eat tiny ones. Soon there would be diseases and the soil would not be healthy any more. Humans need to understand the work that the soil bugs do. We need to look after the good ones so they can keep our soils healthy.



YOU COULD SAY THAT SOIL BUGS ARE IN CHARGE OF SOIL HEALTH!

Sammy Springtail

"We help to break up organic matter and help control nasty soil microbes. There's a lot of us in the soil - more than 100,000 per cubic metre of soil."

MAKING HARMFUL CHEMICALS SAFER

When all the bugs are working properly, they can help clean-up poisons too. There are some nasty parts left over from chemicals used for farming and other industries. Soil bugs change these or hide them so plants cannot get them.

WHAT AFFECTS THE SOIL BUGS AND THEIR WORK?

How many soil bugs there are and what they do, depends on some natural things and some things that humans do.

Natural things that affect Soil Bugs include:

- **Soil Moisture**

When the soil is nicely moist the bugs are happy and do their work properly. When the soil gets too dry the bugs get thirsty. Their bodies dry out and they cannot work properly, and they cannot have babies or they die. If the soil is too wet the bugs cannot get enough air. Some of them stop working and their jobs are not done well. Plant food is not made properly. Plant diseases can happen.

- **Soil Temperature**

If the soil gets too cold, nearly all the soil bugs stop work. Nearly all life in the soil stops and it is like the soil is asleep. In other parts of the world this can happen every winter for months. In Australia this only happens in a few places. Mostly the Australian bugs just slow down through winter.

Things humans do that affect the Soil Bugs include:

• Soil Disturbance

Disturbing the soil just enough to plant a seed or add some fertiliser keeps the soil bugs busy. But mostly humans disturb the soil too much with cultivation. This causes lots of bugs to die and bad bugs to work faster. The Soil Food Web gets out of balance. The soil dries out too much. Organic plant food is lost and bright light can and high temperatures kill lots of bugs that need to stay in the dark underground.

• Organic Matter Loss

Humans cultivate the soil to grow human food. Our food depends on plants. Plants need food that soil bugs make from Organic Matter. When we cultivate soil we lose some Organic Matter. This reduces the food supply for the soil bugs and plants we need. So we should cultivate the soil less. We are learning how to grow the food without too much cultivation now. Loss of organic Matter also reduces the amount of moisture the soil can store.

• Poor Soil Structure

Too much soil disturbance and loss of organic matter causes poor soil structure. This reduces the spaces available for air water and living things to occupy. It makes the soil unhealthy. It can help the "bad soil bugs" which cause crop and soil diseases and pests to flourish.

• Fertilisers

Too much fertiliser or the wrong kind can cause some soil bugs to grow faster and become very busy. Sometimes this upsets the balance between the soil bugs. Sometimes too much fertiliser can make some soil bugs lazy and they do not reproduce enough to balance the SOIL Food Web.

• Herbicides and Pesticides (Plant Poisons and Animal Poisons)

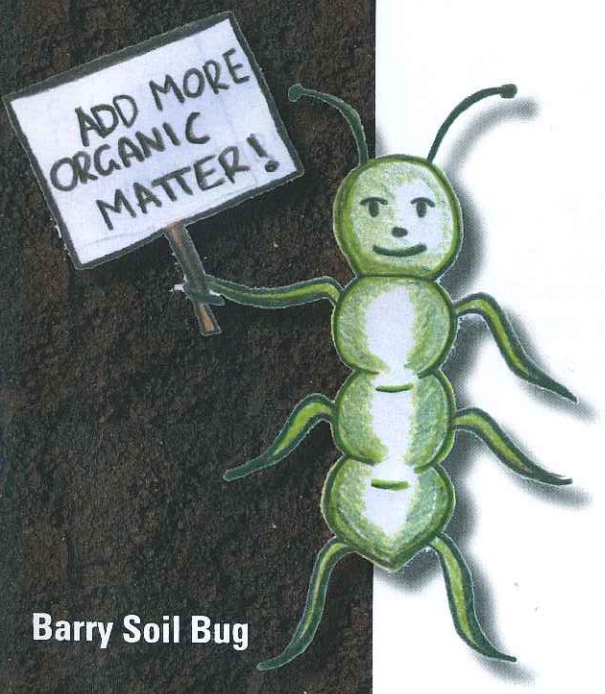
These chemicals are used in agriculture to help grow crops, pastures and animals. Some chemicals can harm soil bugs too. Sometimes the chemicals kill some of the soil bugs. This means the Soil Food Web is messed up. It can take a while for this to be fixed and the soil to become healthy again.

MORE GOOD NEWS ABOUT ORGANIC MATTER

Organic Matter is not just food for soil bugs and plants. It does other important jobs in the soil too.

It can -

- **Reduce Soil Erosion** because it makes soil spongy. More rain soaks in, so water does not run around on top of the soil wearing the soil away.
- **Hold on to Soil Moisture** so the soil stays damp longer after rain. This helps plants get a drink when it has not rained for a while. Holding water longer is like having rain more often. Plants like that!
- **Keep More Air in the Top Soil** so plants and soil bugs can breathe better. This means they can grow better too.
- **Reduce Nitrous Oxide Loss into the Air.** This is a greenhouse gas that changes our climate. Organic Matter makes soil more porous. Water logging is less likely. Water logged soils can lose fertiliser nitrogen into the air as nitrous oxide. When a farmer pays money for nitrogen he does not want to lose it into the air. It costs too much.
- **Improve Nutrient Supply to Plants.** Lots of organic matter and busy soil bugs feed the plants lots of nutrient.
- **Reduce Problems of Acid or Sodic Soils.** Lots of Organic Matter can help plants grow in acid soils where it can be hard to find enough nutrients. It helps plants grow in hard setting soils too, where plants struggle to find air spaces and enough water.
- **Reduce Soil Diseases, Weeds and Pests.** Lots of Organic Matter means lots of busy soil bugs and a healthy Soil Food Web. The plants will then grow well. The plants fill up all the surface spaces they can. There are few spaces where weeds can invade. Bad bugs which cause disease are under control of good bugs.
- **Make the Soil Easier to Work With and Drive On.** Soil with lots of Organic Matter is stronger when it is damp and softer when it is dry. That means a farmer's machinery and tractors will not get bogged easily in damp times. It means the soil stays softer in dry times so plants (and bugs) can still grow and it will not be so dusty.

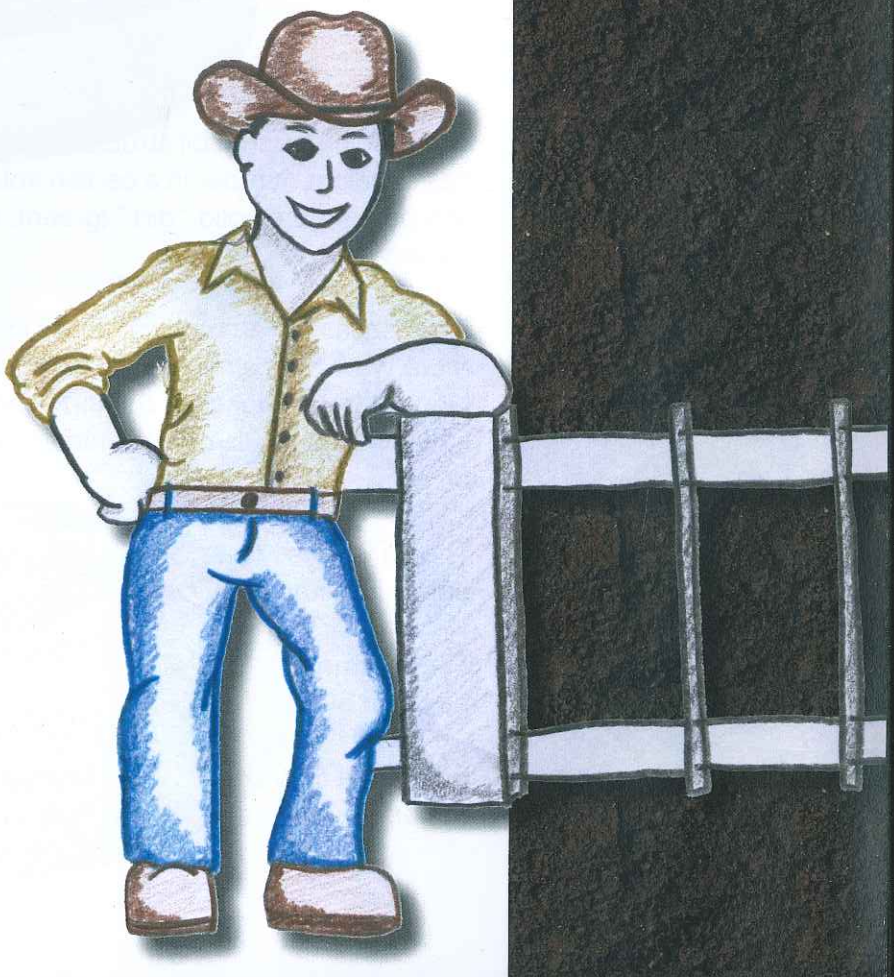


Barry Soil Bug

HOW CAN FARMERS IMPROVE ORGANIC MATTER AND MAKE SOIL BETTER?

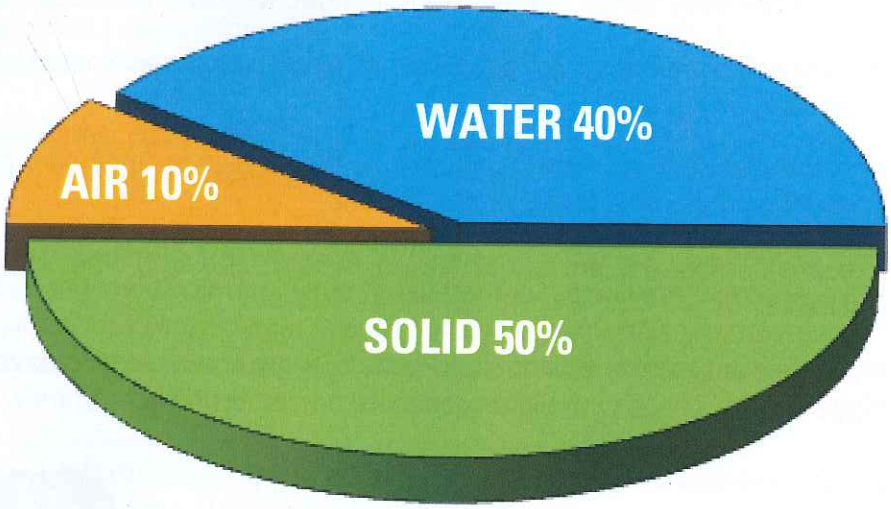
Farmers improve Soil Health when they use conservation farming methods. These methods do five things (one for each finger).

1. Reduce soil disturbance Keep it to a minimum. Mostly it harms soil health
2. Reduce soil compaction Soil squashed by animals and machines is unhealthy.
3. Increase plant growth for groundcover so the surface is never bare but covered with growing plants and/or mulch.
4. Increase number of plant types. Mixed pastures and crop types improve soil health
5. Increase plant root depth and size Plants that grow all year long have bigger roots. Crops with bigger roots are better too.



SOIL STRUCTURE

People are now learning what SOIL needs to be healthy. However, people did not always know. Some people made mistakes with the SOIL. They caused damage to the SOIL health because they did not know.



The first important soil structure measurement is **Bulk Density**. Bulk density has a weight number in a certain volume. If we keep the same SOIL volume and put in more solid "dirt" (green), then there is less room for air and water (yellow & red).

If we squash even more solid dirt into the same SOIL volume, we lose even more water and air spaces, and it gets heavier. (The bulk density number gets bigger!) If we squashed the dirt in so tightly that it turned into rock, we would have no air left. Plants and animals could not live in there because it would all be solid.

The bulk density number for rock is 2.65 grams/cm3 and for good SOIL, it is only 1.2 grams/cm3.

The volume is the same (cm3), but rock has a much higher bulk density number than SOIL.

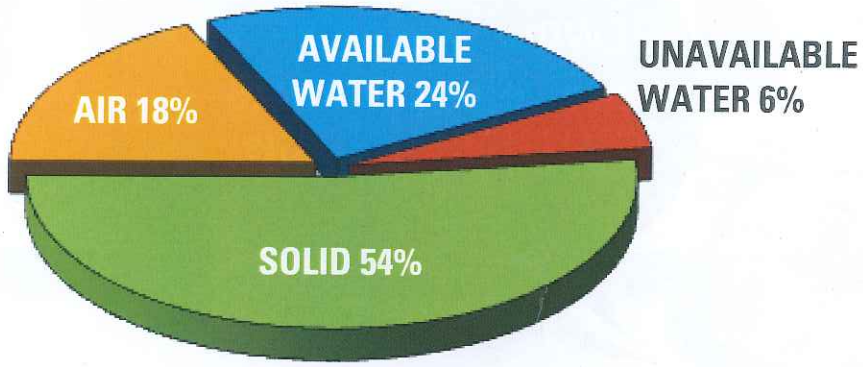
Plants like to grow in SOILS with a low bulk density number. So, they would rather grow in the SOIL (1.2) than in the rock (2.65).

COMPACTION

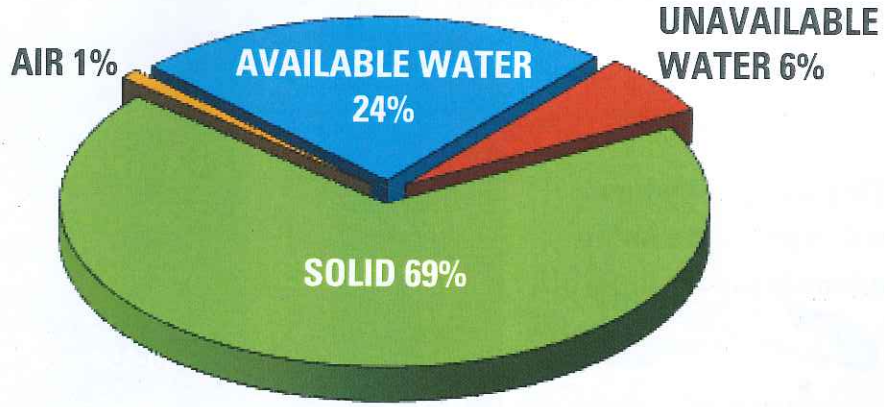
When we pack more "dirt" into a SOIL volume, it is called Compaction. When we compact SOIL, it is harder for plants to grow in, because they cannot get enough air or water.

Water that plants can suck out of the SOIL is **plant available water** or **PAW.** When plants roots have sucked out all they can, there is still some water left that they cannot suck out. It is **plant unavailable water** or **PUW**. When there is only PUW left, the plants start to droop and die, because they cannot suck PUW out of the SOIL.

Scientists measured what happens when a SOIL is compacted. They started with a loamy SOIL with good soil structure, and a bulk density of 1.4 tonnes/m^3 -or grams/cm^3. It had 24% of plant available water, and 18% air. It also had 6% of water plants cannot suck out (PUW - red bit).



When the same SOIL was compacted to 1.8 tonnes/m^3 (see the picture below), the air has been pushed out, but the water has not changed. Plants would not grow well in this SOIL because they need 10% air to grow. This compacted SOIL only has 1% of air left.



NATURAL SOIL STRUCTURE

Some SOILS have a naturally resistant soil structure. They can bounce back from rough treatment like ploughing. This resistance is **buffering capacity**. A buffer is like a protective system for a SOIL.

One SOIL type with naturally resistant SOIL structure is a **deep red volcanic SOIL** made from basalt rocks. Lots of iron and aluminium in the SOIL help it keep a good structure.

Another SOIL type with natural resistance is the **black self-mulching** SOILs in the Darling Downs and Liverpool Plains. Their stability is due to a special type of shrink/swell clay called smectite.

SOIL structure is also more stable if the SOIL has lots of organic matter.

"I wonder how much pressure Wombats put on the ground?"

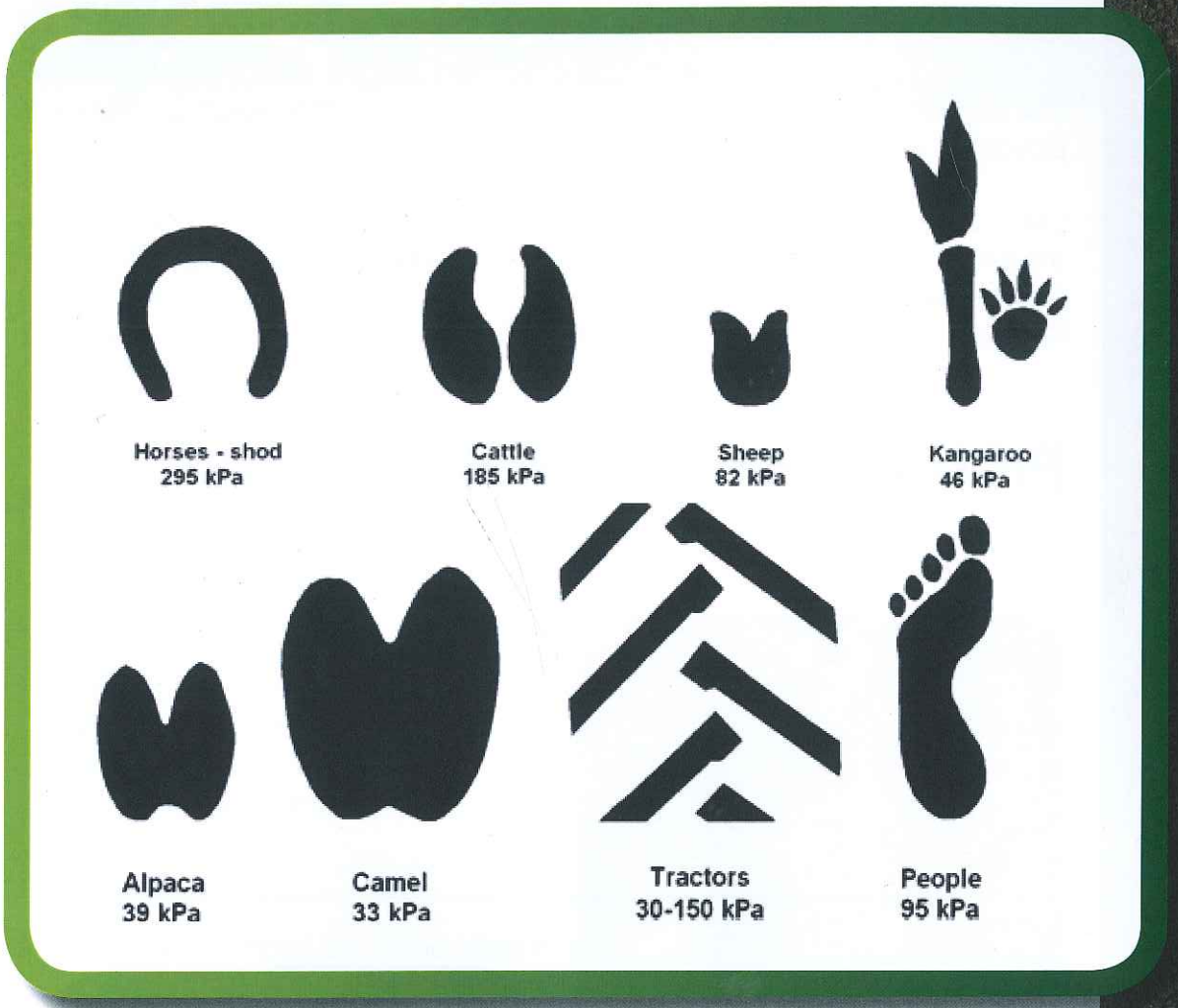
Wazza Wombat

STOCK COMPACTION

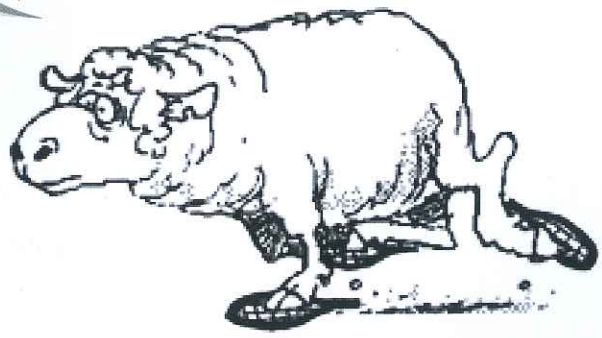
Squashing damp SOIL causes compaction. Cultivating the SOIL and driving machinery over it usually causes compaction. However, cows and sheep can also compact the SOIL. They are heavy animals with small feet. They put more pressure on the ground than tractors.

This list shows how much pressure some animals put on the SOIL.

Horses – shod	295 kilopascals kPa
Cattle	185 kPa
Sheep	82 kPa
Kangaroo	46 kPa
Alpaca	39 kPa
Camel	33 kPa
Tractors	30-150 kPa
People	95 kPa



If sheep wore slippers, the soil would think sheep were camels.

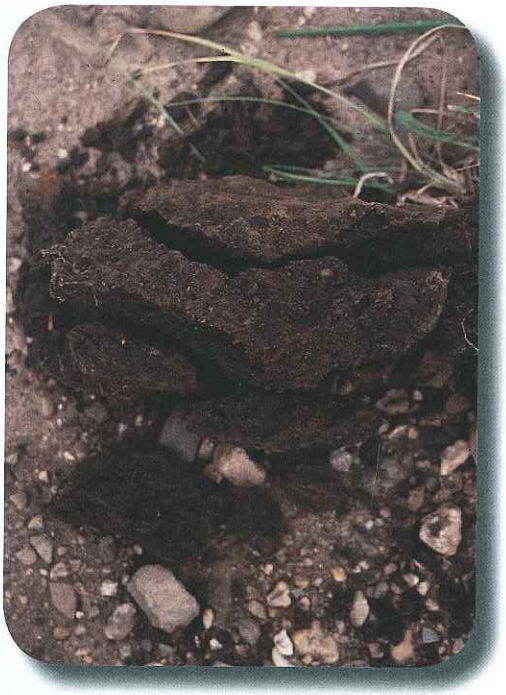


You have to dig down into the SOIL to see where the compaction problem is. The compaction layer for sheep is at about the same depth as for disc ploughs – 10-15 cms.

Cattle compact SOIL deeper than this, and **squash** the SOIL more, leaving the surface rough. The name of the hard layer is a **hardpan or ploughpan**. Some hardpans are naturally formed by chemicals in the soil being washed into layers. These hardpans are too deep for farmers to fix.

PICTURES OF SOIL PLOUGH PANS

This picture shows good soil structure



This picture shows a plough pan in the soil profile.

02 ACTIVITY TWO

MAKE YOUR OWN COMPACTION LAYER/PLOUGHPAN!

It is a simple job to make your own ploughpan! Head out to the garden – ask your parent or carers permission to dig two patches of soil. Once you have dug the two patches, chose one to jump up and down on ten times – try and squash it as much as you can – pretend you are a big John Deere Tractor or a herd of Hereford cows!

Now grab a watering can and a stopwatch. You might need a friend or your brother or sister to either work the stopwatch or do the pouring. Start pouring and start the stopwatch for dug up patch one – the jumped on patch. See how long it takes for the watering can full to soak into the ground. Then do the same for the patch you did not jump on. Record the time taken for each.

Patch one – Jumped On – time taken to soak in = _____

Patch Two – not jumped on – time taken to soak in = _____

Were they different? _____

Why? _____

_____

_____

_____

_____

SOIL STRUCTURE

LOOKING DOWN THROUGH THE SOIL...

When we stand on the earth, we only see the top of the soil. We understand the soil better if we can see what is underneath too. We can do this where a road is cut through a hill. Another good place to see under the soil is on the side of a gully or an eroded creek bank. Sometimes we even dig a special hole called a soil pit to look under the soil.

If you are travelling along a road, look at the road cuttings.

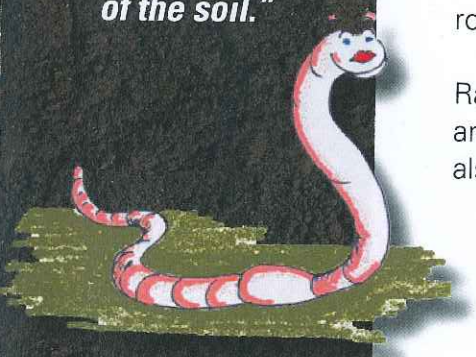
What do you see? Maybe some rocks with a soil layer over the top. If you are near a gully or creek edge what do you see? These are vertical views of the soil (called soil profiles). Some soils form over millions of years on top of their rock parent material. In other places, they form where wind or water has left deeper deposits on flatter ground.

Rocks may be very close to the surface or on the surface. This happens on ridges and hilltops. It tells us that erosion has moved most of the soil away and left it somewhere else. In drier western areas, the road cuttings may show only deep sand. The wind has moved it into sand hills.

Think about the hills being the hard bits being left behind after everything has been washed away.

Billy Slater

"We are another great soil worker, breaking down plant and animal bits and pieces for the health of the soil."



Wendy Worm

WHAT CAN YOU SEE IN A SOIL PIT?

Start looking at the top of the soil surface. Slowly look further down. You will see bands of different colour and soil textures. We call them soil horizons. They are different because they have different amounts of clay, silt and sand. The bands can have different chemicals too. Up the top you will see plant roots, leaves and maybe even some creatures such as worms.

Rain and temperature make the bands as they weather the parent material and soil. The soil horizons are roughly parallel to the land surface. Floods also make different layers of soil along creeks over thousands of years.

The soil horizons may change very sharply. Can you see a sharp colour change? Can you see a texture change such as from a sandy soil to clay soil? Sometimes the horizons are more difficult to see, when there is only a gradual or slight change in the colour or the type of soil.

Soil scientists give these horizons names like O, A, B or C, horizons.

O HORIZON is organic matter and litter from plants and animals at the top of the soil.

A HORIZON is soil near the top with less clay or more sand. It may have more organic matter and more soil pores too.

B HORIZON is soil that often has more clay and the brightest colours.

C HORIZON is parent material or weathered rock below the soil. The soil forms from it.

SOIL TEXTURE

HOW DOES A SOIL SCIENTIST CLASSIFY THESE HORIZONS IN THE FIELD?

The first thing they do is describe the soil texture in each horizon.

Soil texture describes the ingredients in the soil and how much there is of each one. Soil texture is a bit like "soil recipe". Scientists can work this out exactly in a laboratory. However, in the field we work it out by mixing some soil with water in our hand. When it is like firm mud or plasticine, we can feel the ingredients in the soil. The ingredients are sand, loam, clay and organic matter.

- **Sand grains** feel hard and rough and they are noisy when mixed with water. Hold your plasticine ball up to your ear and squish it to hear the sand. We can even see some of these little sand grains.
- **Loam** is made from the same material as sand but it is smaller pieces. This makes it feel silky, and it is not noisy when you scrunch the ball up to your ear.
- **Organic matter** feels very slippery and spongy. Most soils in Australia do not have very much of it.
- **Clay** feels sticky and smooth after it gets wet. You can make a thumb print in it if you press your thumb onto the ball of soil you have made. It can be rolled into thin snakes without breaking.

When we have mixed the soil and water well, we can try to make a "snake" or ribbon with it. Have a look at the picture and give it a try.

We do this by squeezing it from our hand using our thumb and our curled pointer finger. The ribbon will eventually break off, when it gets too long for the soil to hold together.

- Clay soils can make longer ribbons.
- Sand will not make any ribbon.
- Sandy loams make very short ribbons.
- Clay loams make medium length ribbons.

03 ACTIVITY THREE

SOIL TEXTURING!

Try doing this texture test on some soils from different areas – grab some from a hill, a creekline, the middle of a paddock etc.

Doing a variety of soils will give you a good idea of the differences between the types of soil.

Record your texture results and where each soil was found in the table below :

WHERE IS THE SOIL FROM	HOW LONG IS THE SOIL RIBBON	OTHER FEATURES OF THE SOIL
Eg. Down near the creek	Eg. 5 cm	Eg. Very slimy and slippery when wet

SOIL COLOUR

To describe soil color, scientists use a book called the **Munsell Soil Colour Charts.**

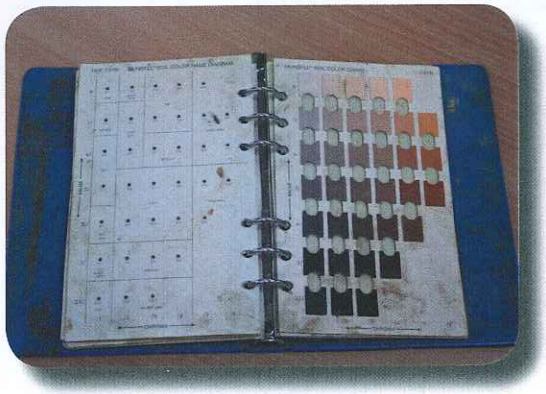
The book has pages with small patches of all the colours a soil could be. Each colour patch has a number. The scientists look in the book until they find a colour patch the same as the soil. They then write down the page and the colour number to describe the colour.

It's just as easy to describe soils using colour words though!

Soil colours can be reds, browns, yellows, greys, blacks and even greens. The colours tell us something about the soil.

These are things like:

- A red clayey (that makes a long ribbon) soil probably has lots of iron and magnesium and is probably fertile – that is, it grows good plants.
- A yellow clayey soil has probably been wet quite often in the past. The water washes the chemicals such as iron and magnesium away, making the yellow colour.
- Soil can be distinctly speckled with different colours like red and yellow, or grey and brown. Scientists call these "mottles". Mottles are when the soil has two or three distinct colours. It shows that the soil was wet, and then dried, many times.
- A grey/olive green colour mean the soil has probably been full of water with no air for a long time.
- Dark brown or black clay soils often come from volcanic rocks and are also fertile.



04 ACTIVITY FOUR

SOIL COLOURS

You can make up your own version of the **Munsell** chart.

Go to the paint shop and gather some colour chip charts of paint colours – in browns, yellows and reds. If you have access to a Munsell Colour Book you can match your chips to the colour description used in the book such as light brown or deep red.

Then get some small soil pieces about 2 – 3 cms in size wet them and see if you can match them to the colours on your sheet.

Smear some of your wet soils on this page to show what colour your soils are.

Record the colours you have identified below. If there are colours not on your sheet add more colour chips that match.

SOIL CHEMISTRY

Lots of plants and animals live in the soil. How well they can grow depends on the soil **chemistry** or **fertility**. Scientists and farmers can do a simple soil fertility test. Then they can tell how well each soil will grow plants. One way to do this is to use a pH test.

Soil pH tests tell us how acid or alkaline the soil is. The tests give us a number between 0 and 14. The pH number is important. It tells us how easy it is for plants to grow in the soil. It tells us how well the soil bugs can feed nutrients to the plants. It helps us understand if the soil is fertile.

The best soil pH number for most plants is between 5½ and 7. This lets the bugs make plant food nutrients that are really easy to absorb. If the pH number is lower than 7, then the soil is acid. If the number is higher than 7, the soil is alkaline. If it is 7 the soil is neutral. Some plants can still grow well in acid or alkaline soil. Many plants find it more difficult and they do not grow so well.

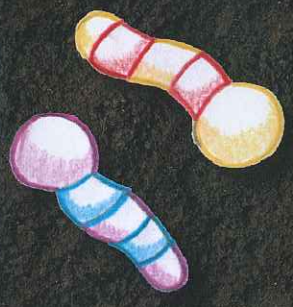
pH Test

There are two ways to do a pH test. The first way is cheap, easy and quick to do. Anyone can do it in a paddock.

The other way is more accurate, but slower. Scientists do it in a laboratory and it costs more. We can do the easy test in a classroom or in your backyard.

The easy pH test mixes a little bit of soil with a green liquid to make a small patch of mud. We sprinkle a white powder on the mud. After a minute or two, the white powder changes colour. We match this colour with a numbered colour patch on a small pH colour card that comes with the green liquid and white powder. The colour gives us a number between 0 and 14. This number is the Soil pH in water.

Most plants grow well if the soil pH is between 5.5 and 7. This is the range when the soil bugs and bacteria are happily doing their job of feeding nutrients to the plants.



If a soil has a pH too far below 5.5, it is an acid soil.
Acid means sour – like Sour Worms!

In acid soils, the bugs and bacteria are not happy. They slow down their work feeding the plants. Then the plants cannot grow properly. In acid soils there is too much of some chemicals (like aluminium and manganese) and not enough of others (like phosphorus and nitrogen).

05 ACTIVITY FIVE

DO YOUR OWN pH TEST

Use a simple pH kit to test three different soils. Gather your soil samples from different places.

Do the test for each one and record below the colour each one turns when you put the white powder on them.

Soil Type One

Soil Type Two

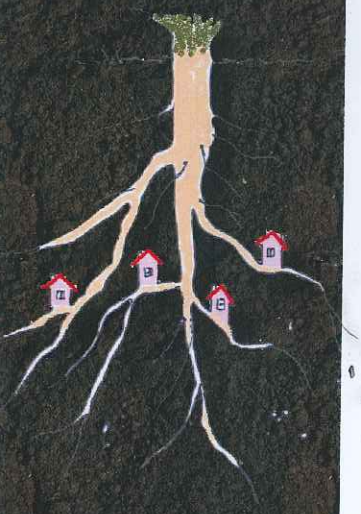
Soil Type Three

NATURALLY ACID SOIL

Some Australian soils are **naturally acid**. Acid rocks make these acid soils. Where the climate is really wet the soil is often acid too. This is because rain rinses nutrients out of the soil. The rain is also slightly acid. It has carbon dioxide from the air in it. This makes carbonic acid which enters the soil with the rain.

Natural Acid Soil has a low pH in the topsoil and in the deep soil. We can find natural acid soils by doing pH tests at the surface and in the deeper soil. In a naturally acid soil the pH numbers will be low all the way down as you dig deeper.

Bacteria are so tiny we need a microscope to see them, but our eyes can see their root nodule houses. They don't really look like houses. They look like little round balls on the side of the roots. These bacteria gather nitrogen food for the plant.



HUMAN MADE SOIL ACIDITY

The following three methods of making soils acid are not natural. They are called **human-made acidity or induced acidity**.

1. If farmers are not careful, they can make their soil more acid. Farmers grow plants and animals and then take them away from the farm to sell. While the plants and animals grow, they suck up nutrients from the soil. Therefore, the farmer is actually selling nutrients from the soil. The nutrients that are sold must be replaced by using fertiliser or other things such as compost. If the farmer does not do this the soil becomes more acid.

2. Another way to make the soil more acid involves the types of plants that farmers grow. "Legumes" such as lucerne or clover have bacteria on their roots called rhizobia. These have the job of turning nitrogen in the air into soil nitrogen nutrients for plants.. The "nutrient joined to nitrogen" is called a nitrate. Nitrates are easy for plants to suck up and use as plant food. But nitrates are also easy for water to rinse out of the soil. If the plants suck up the nitrate first they grow better and that is good. But, if the rain washes away the nitrate first, then the soil loses some "nutrient joined to nitrogen". That is bad. The rhizobia can get more nitrogen from the air but they cannot bring back the nutrient that was washed away. So the soil becomes more acid.

Remember – the more nutrients and good bits being taken out of the soil means the more acid or sour the soil becomes!

3. Some fertilisers (like ammonium sulphate) can make soil more acid too. Farmers need to find out about these fertilisers before they use them so they do not make their soil too acid.

WHAT DO ACID SOILS DO TO PLANTS?

Aluminium poisoning is a common problem for plants in acid soils. Aluminium is a substance found in every soil. Usually plants are not able to suck it up. It dissolves and is poisonous when the soil becomes acid. It can kill plants. It can make them stop growing. Or, it can make them grow very badly. Manganese can cause the same problems in acid soils particularly when they are wet.

Plants cannot work properly in acid soils to get the nutrients they need. Remember most plants work best when soil pH is about 5.5 to 7. If we fix the pH so the soil is not acid, the plants can work better. How can we fix acid soil pH?

FIXING ACID SOIL'S pH

To fix acid soils farmers apply a material called lime. Lime is made of calcium carbonate. You may have seen piles of white lime in paddocks. You might have seen paddocks that are white after the lime has been spread. It is spread as a fine powder. An agronomist or soil scientist works out how much lime is needed depending on how acid the soil is. They can use a soil test result to do this. It is a good idea to fix soil acidity early. If you wait too long, more of the soil becomes acid. Then more lime is needed. This can become expensive.

SOIL STABILITY

Soil can be tested to see how much it changes when it gets wet. This can tell us:

- If it is easy for soil erosion to happen.
- How hard it is for plants roots to get into it.
- If a farm dam made from the soil will collapse when the dam gets full of water.

Scientists test soil stability in a laboratory. We can do a similar test in the classroom using a dish of rain water. To do this just gently put a small crumb of the soil in the dish of water. Then we watch what happens to it.

A few things can happen

- The soil might all fall to pieces and melt into the water. The water might become milky (scientists call this dispersion). This means the soil has very poor stability. It is very erodible. If a dam is made from this soil, it will break. This soil does not have much organic matter in it. It is a good idea to leave the grassland or forest roots in this soil. Do not dig it up to grow crops. If they are dug up with cultivation we might need to add lime or gypsum to the soil so it does not set too hard
- When all or only some of the soil falls to pieces but does not become milky (scientists call this slaking) . This means the soil is not so bad. It is not so erodible. We need to be careful to keep as many plant roots as we can.. Dams made with these soils are less likely to break, but sometimes they might leak. In crops and pastures the best way to look after this soil is build up the organic matter.
- If none of the soil crumb falls to pieces and the water does not become milky, the soil has good stability. It does not change much when it gets wet. It is not very erodible. But if this type of soil is also red, dams made with it might leak badly. Often a soil stays together when it has plenty of organic matter.

These pictures show soils with different levels of slaking and dispersion.

06 ACTIVITY SIX

IS THE SOIL STABLE?

Do the Soil Stability test on a couple of the soils you have found. To do this you will need some rainwater or distilled water, some flat dishes like petri dishes or saucers, and clods of soil. You will also need a watch to measure the time.

Use the following table to record what happens at different times to your soil:

SOIL SAMPLE NUMBER AND WHERE IT WAS FOUND	WHAT HAPPENS STRAIGHT AWAY	WHAT HAPPENS AT ONE MINUTE	WHAT IS HAPPENING AT FIVE MINUTES

MORE ON ORGANIC MATTER AND ORGANIC CARBON

Soil Organic Matter is made from plants, animals, bacteria or other soil bugs, which were once alive. When they die in the soil, the stuff they are made of is changed into "food" for the living soil bugs left behind. The "food" is called Organic Matter. Soil needs a lot of it to be healthy.

There are millions of bugs or soil organisms in a handful of top soil. Most of them are in the top 10 centimetres of soil. There is a HUGE number of these creatures.

We could gather up all the sheep on a sheep farm and weigh them. If we could then gather all the soil organisms on the same farm, they would weigh four times more than the sheep. We need to keep them moist by keeping organic matter in the soil because they do many important jobs to keep the soil healthy and fertile. The smallest soil organisms are bacteria and funghi. They do most of the work to keep soil healthy.

Soil organic matter is important as food for soil bugs, but it does other jobs for healthy soil too. One job it does is to stick soil particles together to improve soil structure. It is like bolts holding a farm shed together.

It also makes soil spongy, so rain soaks in better. More water goes into the soil for plants and animals. Less runs down the hills to make erosion. Organic matter helps soils absorb 50 - 60 mm of rain in an hour.

Spongy topsoil holds more water and has more air spaces. This makes topsoil a better place for animals and plants to grow in. Soils with good organic matter also loose less fertiliser. Also the soil needs less applied nutrients as the organic matter provides nutrients. Soil bugs in a spongy soil can also help the plants suck nutrients from the soil more easily.

Arnie Ant

"Really we are better than Earthworms, turning over lots of soil to improve drainage and fertility. We are soil movers, soil makers, seed sowers - and we keep pests under control too!"

Organic matter helps overcome low soil pH and poor soil stability. Soil with lots of organic matter is less boggy or dusty and so is easier for farmers to use. Soil pests, diseases and weeds are reduced by high organic matter. This is because there are plenty of good bugs taking on the bad ones.

It's also much nicer to dig burrows in!

Wazza Wombat

All organic matter has a thing called carbon in it. You may have heard of soil carbon. Soil laboratory tests are used to work out how much soil carbon there is.

A soil manager such as a farmer can use this to work out how much organic matter there is. Good organic matter content is 3 to 6% in farming topsoil.

Soil Organic Matter % = Soil Carbon % X 1.7

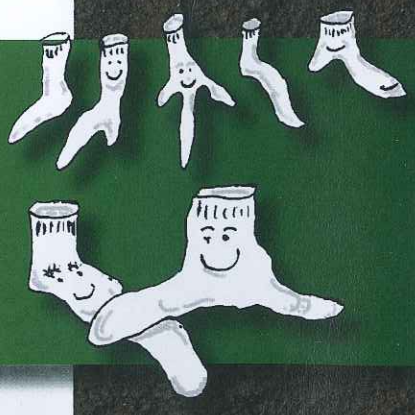
We cannot do a carbon test in a classroom. But we can look at the soil to see if it has lots of plant roots, bugs and fungus growing in it. Topsoil with good organic matter is usually darker too. We can get some idea about our soil organic matter by looking at it.

We can do the following things to increase organic matter:

- Dig up the soil less often
- Squash the soil down less with machinery or grazing animals
- Grow more plant material and keep more mulch on the soil
- Grow more different types of pastures and crops
- Grow more plants with deep roots, which grow all year.
- Use enough fertiliser so there is enough carbon, nitrogen, phosphorus and sulphur in the soil.

FRIENDLY FUNGUS FAMILY

- **We are like warm fluffy socks on the plant roots**
- **We keep unfriendly bugs away from the roots**
- **Like wet socks we keep moisture near the roots**
- **We help roots suck food out of the soil**
- **Scientists call us RHIZOSPHERE**



ACTIVITY SEVEN 07

THE COTTON CLOTH STRIP TEST

Working out which bugs and how many there are in the soil is very complicated. It is usually done in the laboratory. There is a comparison test we can easily do in the playground or in a paddock to see how many bugs there are.

To do the Cotton Cloth strip test first you need some washed and dried calico material. Cut it into 6 strips – each of them about 5cm wide times 15cm long. Now choose two different places to test. One could be in your vegie garden and the other might be in the lawn – on the edge would be best. Take a shovel – you might need an adult to help – and make a deep slit in the ground. Now take the shovel out and wrap the cloth strip around the shovel blade and push the shovel into the ground again. Pull the shovel out and leave the strip behind in the soil...don't forget to leave a little bit of strip poking out of the ground – and to mark the spot so that you know where it is. Do this three times in different slits at this place and then do the same at the other place three times.

Wait about three weeks and then go back to your strips. Carefully dig them out and brush off the dirt. You may need to rinse them in water.

Look at all the strips and compare them. Which ones are more decayed/ rotted down?

Any rotting that has happened is from the soil bugs.

Can you work out why there might be more bugs in one place and less in the other?

NOTES

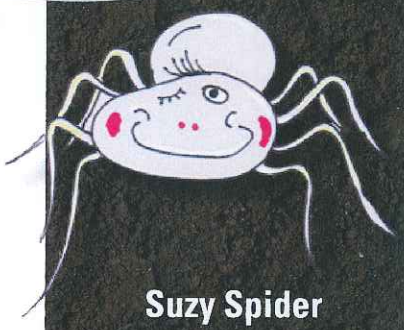
NITROGEN

Nitrogen is one of the most important elements for plants to grow. Every plant needs nitrogen to make the green juice in its leaves. The green juice is called chlorophyll. Plants use chlorophyll to absorb sunlight energy in photosynthesis!

Photosynthesis is how plants make energy using the sun, water, minerals and carbon dioxide

There is lots of nitrogen around in the soil and in the air. Lots of different compounds contain some. However, there are only a few compounds that plants can absorb to get their nitrogen. The main ones are **ammonium nitrogen** and **nitrate nitrogen**. We call these two types **plant available nitrogen**.

The amount of plant available nitrogen depends on how busy the soil bugs have been. It changes with the weather. When it is warm and moist the bugs are busier. Then there is more plant available nitrogen.



Suzy Spider

"Spiders are great pest controllers - eating many of the bad bugs that affect your plants."

Testing soils for plant available nitrogen is very tricky. It keeps changing. The test needs to be done in a laboratory. We cannot do it in a classroom. The soil tests work out how much there is in the sample. But, the answer is only temporary. The nitrogen in the paddock is still changing when the weather changes and the bugs are active.

Ammonium nitrogen does not build up in the soil. It can change into nitrate nitrogen when ever soil conditions are good for plants to grow. **Nitrate nitrogen** is soluble in water. It is easy for rain to wash it away. This reduces the amount of plant available nitrogen.

If a farmer grows crops, the best time to check **nitrate nitrogen** is just before sowing. If farmers check every year at the same time, it is like a "report card' about their farming. If the report card says there is always available nitrogen left over, they do not need so much fertiliser next year. Left over nitrate is not a good idea. When nitrate is washed out of the soil by rain, the soil becomes more acid – or sour - as we have already learnt. Farmers do not want their soil to become more acid.

Only 1% to 5% of total nitrogen is available to plants. The rest is part of the organic matter in the soil. We depend on the soil bugs to change some of it into plant available nitrogen. So as you can see the soil bugs are very important – what would we do without them?

PHOSPHORUS - P

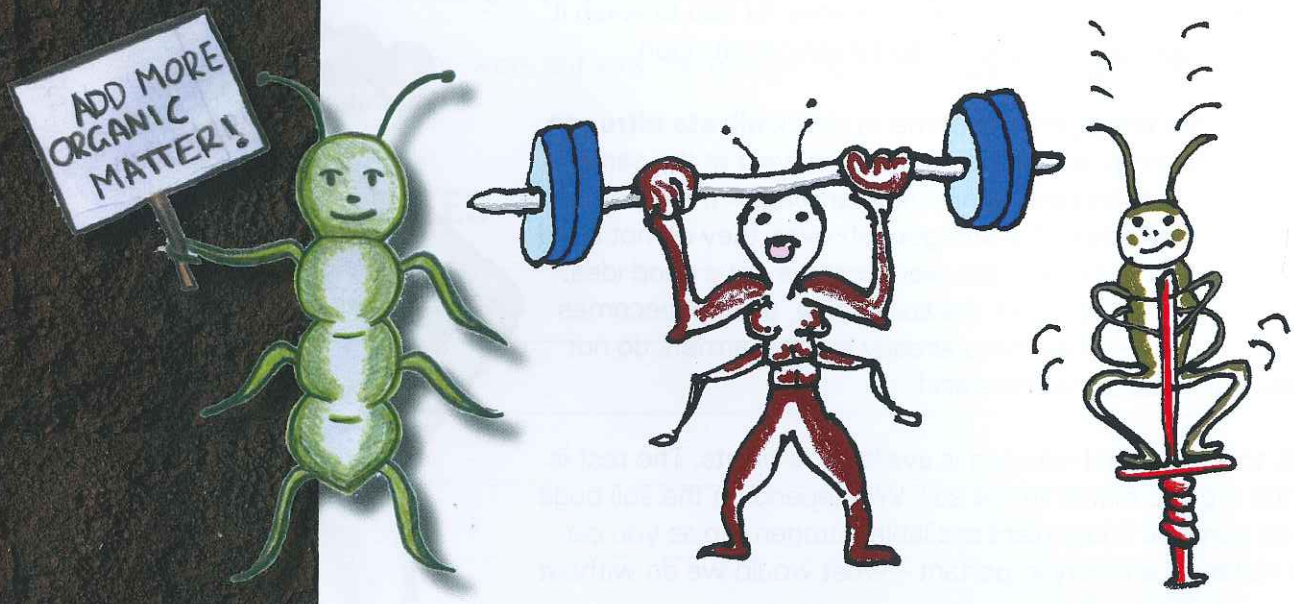
Phosphorus is an essential element for plant and animal growth. For plants it is most important at root tips and growing points. Many Australian soils are too low in phosphorus because they are made from rocks that do not have very much of this substance in them.

Phosphorus is sucked up by the plants in a liquid form. Plants have small root hairs and friendly fungus "socks" on their roots. These help the plant suck in the phosphorus solutions. Plants with very thick friendly "socks" can suck phosphorus better than those without.

Phosphorus can get stuck hard to soils with lots of clay or bright red colours. It is harder for plants to suck phosphorus out of them.

When the soil does not have much **organic matter** plants get most of their phosphorus from fertilisers. When there is lots of organic matter, about half of it can come from soil bugs and the organic matter.

When farmers use up phosphorus for their crops, they need to add more in their fertiliser or other products such as compost. Very sandy soils sometimes lose phosphorus when heavy rain washes it too deep in the soil. Then the plant roots cannot reach it.



Barry Soil Bug **Arnie Ant** **Sammy Springtail**

SULPHUR - S

Sulphur is another substance that is important for plants to grow. Sulphur in the soil is like money in a bank. Some of it is available for plants, quickly and easily. Other sulphur is not available to the plants until the soil bank is ready to let the plants have it. Like money, the sulphur comes into the soil bank in several ways. Some comes from the air. Some comes from the rocks underneath. Some comes from fertilisers and organic matter. A soil laboratory test is like a bank statement. It tells a farmer how much sulphur is in the bank, "ready" for plants to use.

Soil organisms help make the sulphur ready. Farmers who look after the soil organisms, and increase the soil organic matter have more sulphur "ready" to use. Pasture plants and canola need more than other crops. Sandy soils usually have less sulphur. Some bright red clay soils have a lot of sulphur, but it's "stuck" in the red colour, so plants cannot get it. Most plants need to have 5-10 **ppm*** of sulphur "ready" to use. The bank-balance of "ready" sulphur changes during the year. There is more "ready" sulphur in the summer than in the winter. If a soil sulphur test is done in the summer it may look like there is enough "ready", even if it is too low in winter.

* ppm means parts per million or grams in a kilogram

SOIL CHEMICAL BALANCE

Mickey Cricket

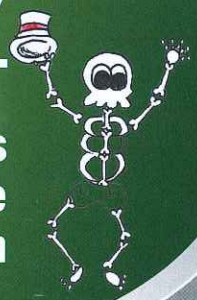
"Crickets are one of the main workers in the soil. We shred plants and leaves so that they breakdown and dig lots of tunnels to let the air in.

Some chemicals in the soil need to be in balance with others. A cricket test match must have 2 batsmen and 11 fielders or it is not a proper test match. The correct balance of batsmen to fielders is 2 to11. Soil that is stable and good to grow plants needs the correct balance for some of its chemicals. Two important chemical balances are the Calcium Magnesium Ratio and the Magnesium Potassium Ratio.

CALCIUM TO MAGNESIUM RATIO

In a good soil this ratio is higher than 2:1. That means Calcium is more than double Magnesium. If this ratio is less than 2:1 the soil would be unstable. It would also be easily erodible. When it dries out it would set hard. Plants would have trouble growing in it because it is so hard. If this ratio is above 10:1 crops do not care much. However, animals grazing on the plants might get a bit sick, because they are not getting enough magnesium.

QUIRKY FACT
our bones are made of calcium



Wazza Wombat

MAGNESIUM TO POTASSIUM RATIO

In a good soil this ratio is higher than 3:2. That means Magnesium is more than one and a half times Potassium. If the ratio is below this, grazing animals can get sick. This is because there is not enough magnesium in the plants.

Did you know that pure potassium is a lightweight silvery metal that is soft enough to cut with a knife?

08 ACTIVITY EIGHT

THE FERTILISER EFFECT!

What can a Nitrogen or Phosphorus Fertiliser do for your plants?

Plant some seeds into six Styrofoam cups/pots. Make sure you use the same pots and the same seeds and the same soil. To do an experiment like this you need to make sure you compare the same with the same. Keep the soil moist but not soaking wet.

Once your seeds have "germinated" - that is – come up, continue your watering program but to three of the pots use water that has a "soluble" fertiliser in it. There are lots of these at garden shops. Soluble means they dissolve in water. Keep watering the other three pots with just plain water.

Keep this up for two weeks. At the end of these two weeks, make the following measurements.

PLANT POT NUMBER	HOW HIGH IN CMS	COLOUR OF LEAVES EG PALE GREEN, DARK GREEN ETC	OTHER THINGS I HAVE NOTICED
1 fertiliser added			
2 fertiliser added			
3 fertiliser added			
4 no fertiliser			
5 no fertiliser			
6 no fertiliser			

Has the fertilizer had an effect on the plants? How?

SOIL SALINITY... HOW SALTY IS THE SOIL

Soil salinity is another important soil property that can also be called electrical conductivity. We can test how salty a soil is because salty water can conduct electricity. We can do this in the classroom or at home in the backyard.

To test the soil we wash the salt out of a soil sample. We use one part of soil and 5 parts of distilled or rain water to do this. Then we use a small electric tester with two metal points. It measures the electric current through the wash water between the two points. More salt means more electric current will flow. We use this to tell how much salt was in the soil.

There are different sorts of salt. Some salts are OK like lime or gypsum. But some are bad like table salt. Salts work like a "magnet for water" dragging the water away. So a plant growing in a salty soil finds it hard to get a drink. It has to suck its water away from the "magnet". That is hard work. Some plants can do this well but most plants do not. Most plants die before they can get enough water to drink.

The chart below shows different types of crops, pastures, fruits and vegetables and the level of salt they can put up with. The crop type column tells you if the crop is sensitive – ie doesn't like the salt, or tolerant ie can put up with the salt.

CROP	CROP TYPE	SOIL SALINITY LEVEL
Turnip, Strawberry, Beans, Carrot	Sensitive crops	Very Low
Clovers, Potato, Grapes, Corn	Moderately sensitive crops	Low
Lucerne, Kikuyu, Phalaris, Grain Sorghum, Rice	Moderately tolerant crop	Medium
Buffel Grass, Oats, Wheat, Perennial Ryegrass	Tolerant crops	High
Barley, Cotton	Very tolerant crops	Very high
None	Generally too saline for crops	Extreme

Clay soils can have much more salt than sands. It does not all wash out to be measured by the salt tester, so the test gives a result which is too low for clays. Even though it does not wash out in the test, it still works as a "water magnet". To fix the test result we have to multiply the tester reading by another number. This other number gets bigger for soils which have more clay in them. Remember that a high salinity reading may not mean you have a salt problem because some salts are okay. You will only have a problem when there is too much bad salt.

CATION EXCHANGE CAPACITY... THE NUTRIENT SWAP SHOP!

Soil nutrients on their own have an electric charge. They are then called ions. They are like the little batteries you put in a watch.
The electric charge makes them work like tiny magnets.

Nutrients can have a positive electric charge or a negative electric charge. The ones with a positive charge are called cations. Some cation examples are:

H^+	- hydrogen ion
K^+	- sotassium ion
Na^+	- sodium ion
Ca^{2+}	- calcium ion
Mg^{2+}	- magnesium ion
Al^{3+}	- aluminium ion

They all have plus signs beside their chemical symbol. It tells us they are positive charge.

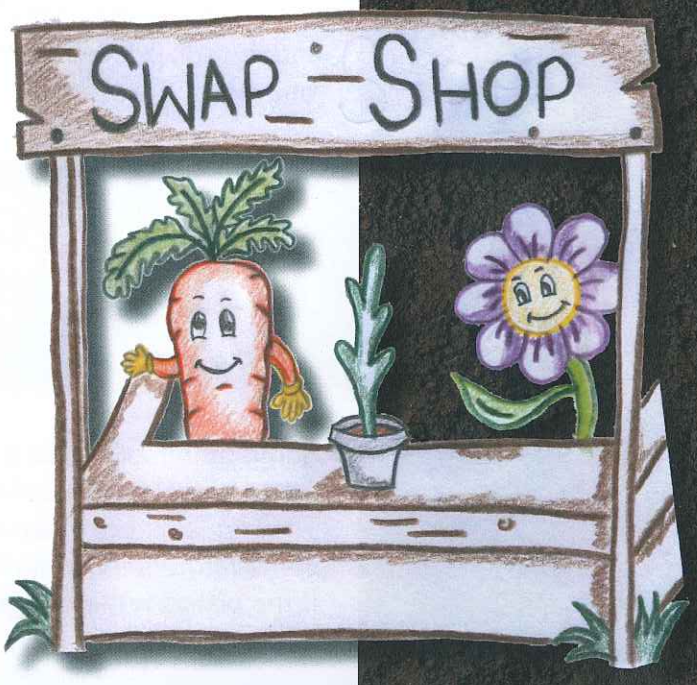
The ones with negative charge are called anions. Some anion examples are:

NO^{3-}	- nitrate ion
Cl^-	- chloride ion
SO_4^{2-}	- sulphate ion

They all have minus signs near their chemical symbol. It tells us they are negative charge.

Let's just talk about the positive charge cations. They are attracted to places in the soil where there is a negative charge. These are places like clay particles and organic matter.

These places are like a Swap Shop. If you lived in the soil you could bring your tiny little cation to the shop, swap it, and take away a bigger better one. If the soil has a really big swap shop, lots of you could do this for a long time. Plants like to go to the swap shop to get nutrients.



Scientists can do a test to see how big the nutrient swap shop is. They call it the Cation Exchange Capacity and they give it a size number. If the soil is fertile it has a big swap shop, and a CEC size number bigger than 20. Usually soils that have lots of clay or organic matter are like this. Plants love to go to clay soil swap shops. They can grow larger and healthier in these soils. It is good if there are lots of different kinds of ions. The plants can then pick out the cations they need. They can grow larger and more healthy in these soils.

Poor soils only have a small swap shop, and a CEC size number lower than 5. They often have mostly small boring cations like H^+ hydrogen ions. Sandy soils are like this. Plants do not have as much fun in these swap shops. There are not as many interesting nutrient cations. That is why sandy soils grow fewer plants, and why they are often small plants.

There are two cations that can cause problems. Too many sodium ions can make the soil unstable, erodible and too hard. (remember sodium is part of salt) Soils with too many sodium ions are called sodic soils. Less than 6% of sodium ions in the swap shop is good. Too many aluminium ions make plants sick. This happens in acid soils with a low pH number. Less than 5% aluminium ions in the swap shop is good.

Wazza Wombat

Farmers can fix these two problems by applying lime, gypsum and increasing soil organic matter. This increases the nutrient swap shop size number (CEC) and the soil pH. Increasing the pH above 5.5, takes most of the aluminium ions out of the swap shop. Then the plants don't get sick.

MICRO-NUTRIENTS

Some other soil nutrients are only needed in very small amounts. They are called micro nutrients. They are still important for plants to grow properly. They are a bit like vitamins for people. To work out how much is needed some farmers try some for a small patch of their paddock called a 'trial plot". If the plants in the trial grow better they know they should use some micronutrient next year.

SOIL SODICITY

Soils with too many sodium ions are called sodic soils. Sodium makes the clay part of the soil weak while it is wet. It turns milky and lets the clay particles block soil holes. The water cannot get in or out very quickly especially when the surface is blocked. Less than 6% of sodium ions in the nutrient swap shop is good. Air can only get in slowly too. These soils are easily damaged by soil erosion. The top of the soil is often hard like a foot path. Little baby plants have trouble growing out through the soil surface when it is dry and hard.

WHAT CAN FARMERS DO TO MAKE SODIC SOILS WORK BETTER?

Sodic soils work best when they are full of roots. The roots need to stay there all the time, even if the land is used to grow crops. Farmers who learn how to do this make their sodic soils work better. When sodic soils get wet the clay in them tries to fill in the spaces where water, air and roots should be. You could call sodic soils.....SPACE INVADERS!

There are some things that farmers can do to make sodic soils work better. They can:

- Increase soil organic matter. The amount of plants and animals in the soil.
- Add lime and gypsum if the soil is clayey. These have better cations in them. They can make the wet clay more stable so it does not invade its own spaces. – do your ribbon test to find out if the soil is clayey.
- Keep the soil totally covered by a shield of plants or mulch. Groundcover reduces erosion by stopping raindrops smashing onto the ground. It gets wet by dribbles through the mulch instead of smashing the soil at 70 kilometres per hour.
- Reduce compaction. Don't squash the soil with animal's feet or farm machinery especially while it is wet. Move the animals onto sandier or rocky soil while the sodic clays are wet.
- Help nature make more spaces in the soil. We can do this with lots of earthworms and ants. We can do it with lots of plant roots such as native grasses, lucerne and safflower.
- Let the soil have natural cracking with wetting and drying cycles. Don't muck up the cracks by ploughing it all of the time.
- Have plants with deep roots that grow all year. They are called perennials.
- Increase native vegetation especially grasses if you are able.
- Choose crops that grow quickly.
- Avoid making soils bare. Don't burn crop and pasture residues and don't have bare cultivated soil . Farmers that are up to date have their soil covered and protected at all times.

Shaun Sheep

Sylvester Soil Clod

ACTIVITY NINE 09

HAVE A CHAT WITH A FARMER!

Meet a farmer and interview them about how they manage their soils.
Ask them the following in the interview -

How many different colour soils do you have – what colours are they?

How many different textures of soils do you have – what are they?

What sort of problems do their soils have?

How do you fix these problems in your soil?

You may also be able to ask them if they have a farm plan on a satellite picture – either printed out or on their computer. This will show soil types and the other issues farmers need to think about on their farm.


I hope you've learned lots of interesting things about soil!