

# Healthy Country

managing the land for healthy waterways

## FarmFLOW

growth through good practice

### What's living in your soil?

Soils have a greater diversity of living organisms than above ground. The living part of the soil is very complex and dynamic.

#### Did you know?

- Soil organisms are concentrated in the top 10 cm of soil with 75% of total soil organisms in the top 5 cm.
- The weight of organisms under one hectare of soil can be one to two tonnes.
- In one teaspoon of soil there can be 800 million bacteria, 800 000 fungal units, 1300 nematodes, 1000 to one million protozoa, 137 mites and one ant.
- 75-90% of soil organisms are bacteria and fungi.
- In agricultural soils there may be more than 1000 arthropods (beetles and bugs) in the area under your feet.

#### More about soil organisms

Soil organisms include bacteria, fungi, earthworms, nematodes, protozoa and arthropods (beetles, spiders, ants, centipedes and millipedes). These organisms range in size from bacteria (0.000001 mm) to giant earthworms (1 m). Soil organisms are classified into four groups: microflora, microfauna, mesofauna, macrofauna (Figure 1).

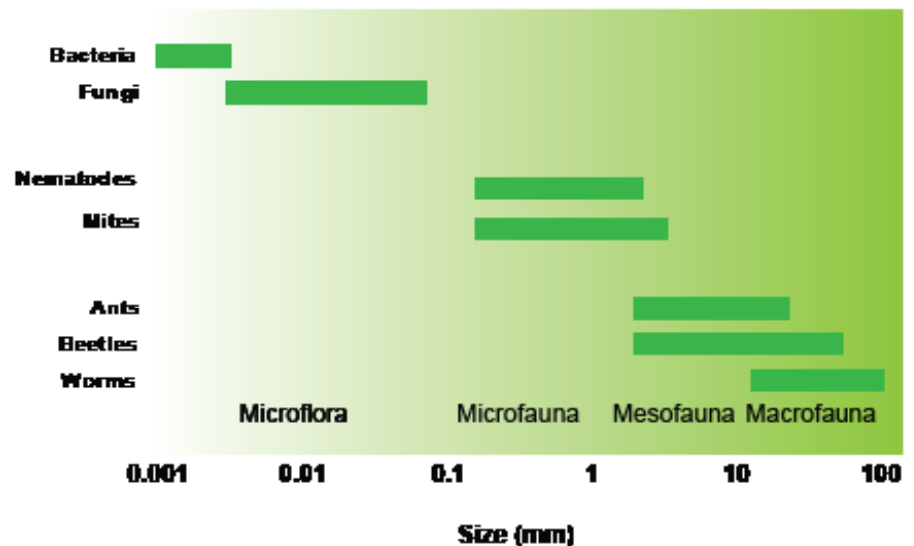


Figure 1. Groups and size range of typical soil organisms. Source: Tony Pattison, Agri-Sciences Queensland, DEEDI

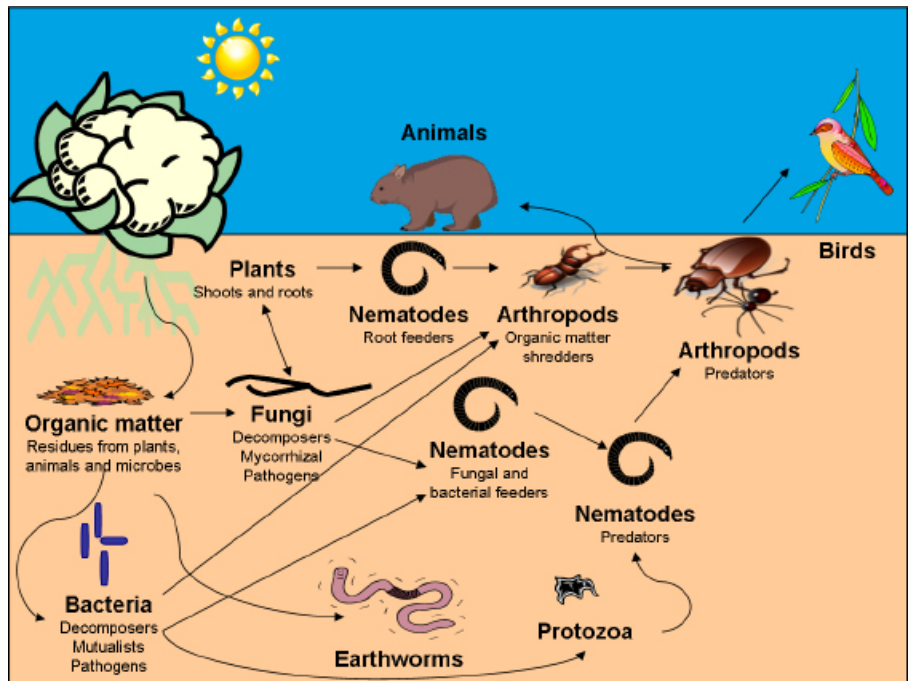


Figure 2. Soil food web.

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Healthy Country partners:



## Bacteria

Bacteria are among the smallest and most numerous soil organisms. Most are found in the top 10 cm close to organic matter. Bacteria can be very fragile or able to withstand extreme conditions. Some can remain dormant for decades until conditions are favourable.



There are various types of soil bacteria:

Bacteria group	Characteristics
Decomposers	<ul style="list-style-type: none"> <li>most soil bacteria are decomposers</li> <li>break down organic matter into available nutrients</li> <li>cycle nutrients in the root zone</li> <li>some can break down pollutants</li> </ul>
Mutualists	<ul style="list-style-type: none"> <li>form mutually beneficial links with plants, e.g. <i>Rhizobium</i> and legumes to fix nitrogen gas from the air into plant available N.</li> </ul>
Pathogens and disease suppressors	<ul style="list-style-type: none"> <li>some cause plant diseases</li> <li>some can suppress plant diseases</li> </ul>
Anaerobic bacteria	<ul style="list-style-type: none"> <li>bacteria that don't need oxygen</li> <li>favoured by wet, poorly drained soils</li> <li>can produce toxins that limit plant growth &amp; cause disease</li> </ul>



Nematodes are distinguished by different mouthparts that match their food sources.

## Fungi

Fungi are microscopic cells that grow in long threads or strands called hyphae. These absorb nutrients from plant roots, organic matter or the soil. Fungi convert organic matter into forms that other organisms and plants can use.



There are three groups of fungi:

Fungi group	Characteristics
Decomposers	<ul style="list-style-type: none"> <li>convert organic matter into fungal growth, carbon dioxide and organic acids</li> <li>needed to degrade woody organic matter</li> <li>take up and store nutrients in the soil</li> </ul>
Mutualists	<ul style="list-style-type: none"> <li>form mutually beneficial links with plants</li> <li>obtain carbon from plants</li> <li>protect plant roots from pests and diseases and increase plant nutrient uptake e.g. mycorrhizal fungi; these fungi form links with 90% plants except for the brassica family (e.g. mustard, canola, broccoli), and chenopod family (spinach, beets).</li> </ul>
Pathogens	<ul style="list-style-type: none"> <li>attack crop plants and can cause significant agricultural loss through reduced growth/yield or plant death, e.g. <i>Sclerotinia</i>, <i>Verticillium</i>, <i>Phytophthora</i>, <i>Rhizoctonia</i> and <i>Pythium</i></li> </ul>



## Protozoa

Protozoa are single celled organisms ranging from 5 to 500  $\mu\text{m}$  in diameter. They feed mainly on bacteria but also other protozoa, organic matter and fungi. Protozoa release nitrogen from the bacteria they eat which is then available to plants and other soil organisms.

Protozoa are classified into three groups based on their form:

- ciliates are hairy
- amoebae are blobs
- flagellates have 'tails'.

## Nematodes

Nematodes are very small types of worms about 50  $\mu\text{m}$  in diameter and 1 mm in length. They are able to adapt to changing soil conditions.

Nematodes feed on bacteria, fungi, other organisms and in some cases plant roots. Nematodes are distinguished by different mouthparts that match their food sources. For example, fungal and root feeding nematodes have piercing structures to puncture cells while nematodes that feed on bacteria have tube like structures to suck in bacteria.

Most nematode species have beneficial roles but little is known about them. Due to their detrimental effects on agriculture, more is known about the few species that cause plant disease.

There are three groups of nematodes:

Nematode group	Characteristics
Microbe feeding	<ul style="list-style-type: none"> <li>most abundant in the soil</li> <li>feed on bacteria and fungi &amp; add to available nutrients and organic matter</li> <li>improve soil structure, water infiltration and drainage</li> </ul>
Predaceous	<ul style="list-style-type: none"> <li>feed on other nematodes, bacteria, fungi and protozoa</li> <li>add to available organic matter and nutrients.</li> <li>can be involved in suppressing pest nematode species</li> </ul>
Parasitic	<ul style="list-style-type: none"> <li>tend to be pest species</li> <li>damage plants by feeding on roots; disease causing fungi and bacteria can then enter the plant</li> <li>farm management practices encourage parasitic nematodes over other species</li> </ul>

### Earthworms

There are over 7000 earthworm species, from 2 cm to 1 m in length. Earthworms are the major organisms involved in breaking down organic matter and recycling the nutrients in it. They obtain nutrients from the bacteria and fungi that feed on organic matter. Earthworms significantly improve soil structure, water holding capacity and infiltration, nutrient cycling and plant growth.



### Arthropods

Arthropods refer to those bugs that have jointed legs and an exoskeleton. They range in size from microscopic to several centimetres in length and include beetles, ants, spiders and mites, centipedes and millipedes. Arthropods have different functions in the soil. They can be:

- organic matter shredders
- predators
- herbivores
- fungal feeders.



Most soil-living arthropods are predators and feed on fungi, worms or other arthropods. Fewer species of arthropods are root feeders and organic matter shredders. Arthropods improve soil by aerating and mixing the soil, regulating populations of other organisms and shredding organic matter.

### Where to now?

The next time you are in the field, grab a handful of soil and consider the huge diversity of biological activity you are holding in your hand some of which probably have not been named yet!

### More information

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### Acknowledgements

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25 600 million bacteria,  
25 600 million fungal units,  
up to 32 million protozoa,  
10 400 nematodes,  
4384 mites and  
32 ants  
could be calling this  
handful of soil home!