

Science

Year



Department of **Primary Industries and Regional Development** Department of **Training and Workforce Development** Department of **Education** 

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# Resources overview: Soils – the basis of food production

# **PRIMED** mission

To increase student understanding of agriculture, fisheries, fibre, forestry and food (primary industries) careers to enable Year 7–12 students to make informed career-pathway choices.

These resources provide rich tasks focused on the *Western Australian Curriculum* within a primary industries context.

# Soils - the basis of food production

This series of activities challenges students to engage with the *Western Australian Science Curriculum* by becoming soil scientists. Through investigating soils as dynamic ecosystems teaming with life, students are able to gain a deeper understanding of the complexities of the biological and physical world and how humans interact with it to sustainably produce our essential food and natural fibres.



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## **Curriculum links**

This resource set is designed to be a learning pathway for Year 7 science students to develop their understanding of the Western Australian Curriculum **Biological sciences** content strand content descriptors:

- Classification helps organise the diverse group of organisms (ACSSU111)
- Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions (ACSSU112)

### It also engages students with the Science as a human endeavour content descriptors:

- People use science understandings and skills in their occupations and these have influenced the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management (ACSHE121).
- Scientific knowledge has changed peoples' understanding of the world and is refined as new evidence becomes available (ACSHE119)
- Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE223)
- Solutions to contemporary issues that are found using science and <u>technology</u>, may impact on other areas of society and may involve ethical considerations (ACSHE120)

It further allows development of the Science inquiry skills integral to the year 7 Western Australian science curriculum.

## **Resource set structure**

The resource set is structured around constructivist learning principles using a 5-E's instructional model: engage, explore, explain, elaborate and evaluate.

- 1. Students' interest and minds are **engaged** in soils as the basis of food production by examining soil fauna and the problem of agricultural soil degradation.
- 2. Students **explore** what they know about the organisms that live in the soil by sampling, extracting and identifying soil fauna. They compare soils from different locations and make inferences from their observations about soil health.
- 3. Students **explain** how classification systems are used to identify soil types and soil organisms and why these are important for primary production. They then explain how the various soil organisms interact with one another via food chains and food webs to produce healthy soils.
- 4. Students undertake problem-solving activities to elaborate on a range of concepts such as:
  - soil pest species (e.g. nematodes) and soil productivity
  - the importance of soil fauna biodiversity and the role of different microorganisms-
  - agricultural systems and introduced pests (effects on food chains, soil)
  - beneficial versus pest species
  - relevant careers opportunities (e.g. agronomist, soil biologist, regenerative farmer)
  - restorative land-management practices
  - classification systems used by Aboriginal and Torres Strait Islander Australians and how these differ with respect to approach and purpose from those used by contemporary science.
- 5. Students evaluate their understanding of the targeted science outcomes.



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Educational process	Teaching and learning activities	Teacher resources / Student activities
Engage students and elicit prior knowledge	Module 1: Soils as ecosystems (2 hours) Students are introduced to the concept of soils in Western Australia as dynamic ecosystems. They first view a video that challenges them to consider why soils are vitally important as a fundamental resource for food production. Students go on to consider what the world would look like if there were no soils. This occurs through group discussion; various activities, such as a glossary activity; and considering questions which extend their understanding of how it is vital for Western Australian primary producers to maintain the biodiversity of the soil biome.	<ul> <li>PowerPoint presentation: <ul> <li>1.0 Soils as ecosystems</li> </ul> </li> <li>Student worksheets: <ul> <li>1.1 What is soil and why is it important?</li> <li>1.2 Glossary activity</li> <li>1.3 Extension questions</li> </ul> </li> </ul>
Explore Provide hands-on experience of the phenomenon	<ul> <li>Module 2: Investigating soil (3 - 4 hours)</li> <li>Students are challenged to be soil scientists, discovering the vital role of soil scientists in assisting primary producers to maintain soil health and biodiversity. They are also introduced to other related careers.</li> <li>Students design and conduct a soil science investigation. Two investigation processes are provided. The first is a simple exercise where students are taught how to take a soil sample and how to extract soil invertebrates from it. Students can then compare different soil types to look for correlations between soil type and invertebrate abundance and diversity. The second investigation is more complex, allowing for extension of student understanding. It involves examining a range of soil abiotic and biotic factors. Assistance for this activity is accessed via the Grains Research and Development Corporation (GRDC). Students can explore four activities designed to emulate the field tests used by grain growers, agronomists and soil scientists.</li> </ul>	<ul> <li>Video: <ul> <li>2.0.1 Investigating soil: Sampling and extracting soil invertebrates</li> </ul> </li> <li>Teaching guide: <ul> <li>2.0.2 Soil health investigation</li> </ul> </li> <li>Student worksheets: <ul> <li>2.1 What do soil scientists do?</li> <li>2.2 Soil health investigation: Extraction and examination of soil fauna</li> <li>2.3 Soil health group investigation framework</li> </ul> </li> </ul>



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Educational process	Teaching and learning activities	Teacher resources / Student activities
Explain 1 Develop and consider scientific explanations for why and how living things are classified	<ul> <li>Module 3: Classifying living things (2 - 3 hours)</li> <li>Video and collaborative learning activities help students examine the importance of classification of species for primary production. They explore the use of keys to identify unknown species, particularly insects, which may lead to biosecurity problems for primary industry. As a practical application, students use a key to identify the invertebrates found in their collected soil samples (from Activity 2).</li> <li>Aboriginal classification systems are introduced to students as an alternative way of looking at plant and animal species classification.</li> </ul>	<ul> <li>Student worksheets:</li> <li>3.1 Classifying living things</li> <li>3.2 Using a dichotomous key</li> <li>3.3 Key to soil invertebrates</li> </ul>
Explain 2 Develop and consider scientific explanations for why and how life on Earth interacts through food chains and webs	Module 4: Food chains and food webs (1 hour) Using the context of soil health in Western Australia agricultural ecosystems, students examine the key ideas of interdependence and interconnectedness of life on Earth through food chains and food webs.	<ul><li>Student worksheets:</li><li>4.1 Food chains and food webs</li></ul>





Educational process	Teaching and learning activities	Teacher resources / Student activities
Elaborate Extend understanding to new contexts or make connections to additional concepts	Module 5: Ecosystem interactions (3 - 4 hours) In this activity students examine the complex relationships occurring in soils which result in healthy soils. Students investigate how a soil ecosystem can become unbalanced, the effects of invasive plant or animal species, and management of invasive species by Aboriginal and Torres Strait Islander peoples. Through further collaborative group discussion students examine, in more detail, agricultural ecosystems and how these can be managed to be better balanced and more sustainable. They examine how modern soil regenerative practices can conserve, restore and regenerate soils.	<ul> <li>PowerPoint presentation:</li> <li>5.0 Ecosystem interactions</li> <li>Student worksheets:</li> <li>5.1 Symbiotic relationships</li> <li>5.2 Soil disturbance effects</li> <li>5.3 Keeping ecosystems balanced</li> <li>5.4 How can we conserve, restore and regenerate our soils?</li> <li>5.5 KWHL Chart</li> <li>5.6 Ecosystems key terminology review</li> </ul>
Evaluate Students re- represent their understanding and reflect on their learning journey	Module 6: What have I learnt? (1 hour) This activity is a student self-assessment focussing on the key learning from this series of activities.	<ul> <li>Student worksheet:</li> <li>6.1 Self-assessment: Soils – the basis of food production</li> </ul>



# Teaching guide: Soils – the basis of food production

Learning sequence and resources



#### **Module focus**

This module is designed to engage students by posing questions to elicit prior knowledge about soils and why soils are important as a fundamental resource for food production. Students are introduced to the real-world problem of worldwide soil degradation and its impact on agricultural food production.

#### Learning intentions

Students will be able to:

- describe soil as a complex mixture of both abiotic and biotic components
- explain that various feeding relationships combine to form a complex soil ecosystem
- explain that the majority of our food supply is dependent on a healthy soil environment
- infer that the soil ecosystem is fragile and that human intervention may lead to an unbalanced system
- use appropriate scientific language to describe their understanding.

#### **Background information**

Soil is a non-renewable resource that can take thousands of years to form. It is a complex environment containing both abiotic and biotic components. The abiotic components of soil are formed from the weathering of rocks by wind, water and temperature changes. Abiotic components include minerals, clay, silt and sand. Over time, soil microbes and plant roots create a complex ecosystem that attracts other living organisms such as nematodes and earthworms. This complex food web helps plants to thrive, breaks down dead organic matter and recycles nutrients back into the environment.

The ability of soil to support plant and animal life is lost through increased salinity, acidification, and chemical pollution and loss of the soil ecosystem. Soil health is intimately linked to the health of the soil ecosystem. The soil ecosystem is the community of organisms that reside in the soil. These organisms include bacteria, fungi, nematodes, protozoa, arthropods and worms. The soil ecosystem depends on primary producers such as plants, moss and lichen. It also has a symbiotic relationship with plants: plants provide organic compounds that are food for microbes; the microbes break down organic compounds to make food for the plants. Plants and the soil ecosystem are therefore highly interdependent.

(Information source: Soil Science Australia, *Soils in Food Chains* (Teachers guide) available: < <u>https://www.soilscienceaustralia.org.au/training/soils-in-schools/teacher-guides/</u>>

#### **Equipment required**

- Computers, internet connection
- Projection device
- Lynette Abbott video (mp4): Soil Health Animation 1 What is in soil and what does it do? (this video is embedded in slide 4 of PowerPoint presentation: 1.0 Soils as ecosystems)
- PowerPoint presentation: 1.0 Soils as ecosystems
- Student worksheets:
  - 1.1 What is soil and why is it important?
  - 1.2 Glossary activity (printed in A3 size)
  - 1.3 Extension questions





#### Instructions for suggested activities

- Initial class discussion introduce students to the concept of soils and why they are important as a fundamental resource for food production.
- Show students the Lynette Abbott video (mp4): Soil Health Animation 1 What is in soil and what does it do? (PowerPoint slide 4)
- Introduce students to the ideas of soils as ecosystems containing both living (biotic) and nonliving (abiotic) components.
- Students work in small groups to suggest some familiar foods and how these can be linked to soil (foods might include: bread, milk, potatoes, hamburgers, chicken).
- Model how one of these foods could be traced to form a food chain.
- Ask students to consider the problems on slide 5 of the PowerPoint
- Using the *PowerPoint 1.0 Soils as ecosystems*, introduce students to the key concept of soils as complex ecosystems containing a complex biome.
- Students complete the student worksheets:
  - 1.1 What is soil and why is it important?
  - 1.2 Glossary activity (Printed in A3 size)
  - 1.3 Extension questions

## Module 2: Investigating soil



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#### Module focus

In this module students are challenged to design and conduct a science investigation into soils.

This soil health investigation allows students to collaboratively demonstrate their understanding of the *Western Australian Curriculum* **Science inquiry skills** content descriptors (refer to page 1).

You need to be flexible and tailor the investigation to suit the ability levels of your students and the amount of time available. To assist this outcome, two investigation processes are provided. The first is a simple exercise where students are taught how to take a soil sample and extract soil invertebrates from it. Students can then compare different soil types to look for correlations between soil type and invertebrate abundance and diversity.

The second investigation allows for extension of student understanding. As such, it is more complex and examines a range of soil abiotic and biotic factors, such as:

- defining the soil texture
- determining the soil pH
- investigating the soil nematodes and making an assessment of the soil health.

A detailed set of student investigations of this nature is described in the Grains Research and Development Corporation (GRDC) resource *The science of living soils* — *investigating soil characteristics and health by identifying its macro and micro invertebrate populations* downloadable at: <<u>https://grdc.com.au/resources-and-publications/all-publications/educational></u>

#### Learning intentions

Students will be able to:

- identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge
- collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, while ensuring that safety and ethical guidelines are followed.







# Background information

Soils contain five main components:

- mineral particles such as sand, silt and clay
- organic matter dead and decaying plants, animals and animal products
- water
- air this fills the space (or pores) between the soil particles
- organisms living organisms such as micro invertebrates and macro invertebrates.

These five components constantly interact with one another and influence the overall soil composition.

Soils host a quarter of the world's biodiversity. Over 1000 species of invertebrates can be found in a single square metre of forest soils. A single gram of soil may contain millions of individuals and several thousand species of bacteria. A healthy soil contains 'tens of species' of nematodes.

Soils are important for food security and are essential to support many diverse ecosystems. The Food and Agriculture Organization (FAO) of the United Nations states that healthy soils are the basis for healthy food and that 95% of the world's food is directly and indirectly related to soils.

(Source: GRDC resource – The science of living soils – investigating soil characteristics and health by identifying its macro and micro invertebrate populations.)

**Equipment required (for each group of students):** Part 1: Soil sampling:

- sampling ring (made from PVC piping or other suitable material)
- trowel
- scraper
- permanent marker pen
- plastic freezer bag and tie
- wooden or plastic cutting board
- rubber mallet
- safety equipment (safety glasses, mask, gloves)

Part 2: Extracting soil invertebrates:

- plastic funnel and large plastic beaker (made from a large plastic drink bottle)
- 70 mL collecting container with a lid, with 1 cm plaster of Paris and charcoal mix (alternatively a mixture of 70% alcohol if you do not want to observe living animals)
- 1 mesh (aluminium flywire)
- 2 gauze swabs
- microscope or heat lamp

#### **Resources required**

- 2.0.1 Investigating soil: Sampling and extracting soil invertebrates (video)
- 2.0.2 Teaching guide Soil health investigation
- Student worksheets
  - 2.1 What do soil scientists do?
  - 2.2 Soil health investigation: extraction and examination of soil invertebrates
  - 2.3 Soil health investigation framework



#### Instructions for suggested activities

There are various opportunities for students to work collaboratively in small groups throughout this activity. Soil samples collected by students should be retained for use in Module 3.

Detailed instructions for teachers and/or school laboratory technicians are described in the Teaching guide 2.1 - Soil health investigation.

Before commencing the practical components of this module, students should:

- complete *Student worksheet 2.1 What do soil scientists do?* which gives useful background information on the role of soil scientists
- watch the video 2.0.1 Investigating soil: Sampling and extracting soil invertebrates

## Module 3: Classifying living things

(Approximately 2 - 3 hours)



#### Module focus

In this module, students will discover the basic principles of biological classification systems in use today and apply these principles to identifying the range of invertebrate organisms found in their soil samples (from Module 2).

#### **Learning intentions**

Students will be able to:

- explain the reasons for classifying, such as identification and communication
- group a variety of organisms on the basis of similarities and differences of particular features
- classify using hierarchical systems such as kingdom, phylum, class, order, family, genus, species
- use scientific conventions for naming species
- use provided keys to identify soil organisms surveyed in a local soil sample
- explain the classification systems used by Aboriginal and Torres Strait Islander Australians and how they differ with respect to approach and purpose from those used in contemporary science.

#### **Background information**

Millions of species make up the global biodiversity of our planet. So scientists may understand the extent and complexity of life on Earth, common systems of classifying organisms have been developed.

If common systems are used, scientists can more easily identify new species, identify pest species that may disrupt ecosystems, and communicate their ideas with other scientists and the community about their discoveries.

Biologists who study the classification of living things are called taxonomists. Classification is the process of putting things into groups and is useful in many areas of life. When taxonomists discover a new plant, animal or microorganism, they describe it and give it a name.

Correctly identifying potential pest species is vitally important for maintaining the biosecurity of Australia's primary industries. Each year, invasive pest species cause considerable damage to farmers' produce. For this purpose, taxonomists use various methods – including classification keys – to identify species that may be harmful to our agricultural industries.



Scientific naming of organisms uses Latin or ancient Greek. These languages are used because they are languages that are no longer spoken and so the meanings of the words don't change over time. The naming also gives information about the organism. For example, the scientific name of the red kangaroo found across much of mainland Australia is *Macropus rufus: Macro* means large, *pus* means foot, and *rufus* means red.

Biological species names have two words. This is called 'binomial nomenclature'. The first word is the genus name and the second is the species name. The genus name always begins with a capital letter; the species name always begins with a lower-case letter. The full name is also italicised. For example, the species name for dog is written as *Canis lupis*.

Taxonomists sort living things into groups to help them make sense of the millions of species on Earth. A hierarchical system of groups is used. The first group, the' kingdom level', has many species within it. Currently taxonomists sort all living things into five different kingdoms – *Animalia*, *Plantae*, *Fungi*, *Protista* and *Monera*.

The kingdom level of classification contains the largest number of organisms. The kingdoms are divided into smaller groups in which the organisms are more similar. The second level of classification is into phyla (in plants, the phyla are called divisions). Phyla and divisions are then divided into classes; classes are divided into orders; orders are divided into families; families are divided into genera (plural of genus); and genera are divided into species. At each new level of classification there are smaller numbers of organisms and the organisms become more similar.

(Source: Simple English Wikipedia, the free encyclopedia – Taxonomy, available online at: <<u>https://simple.wikipedia.org/wiki/Taxonomy#:~:text=Taxonomy%20is%20a%20branch%20of,class</u> ifying%20things%2C%20especially%20classifying%20organisms.&text=This%20name%20is%20p art%20of,places%20can%20understand%20each%20other>)

Aboriginal and Torres Strait Islander classification systems differ in some ways from conventional scientific classification systems. Aboriginal Australians recognise that there are thousands of plant species in the bush. Desert Aboriginal Australians and scientists both have ways to group or classify these plants. These groups are based on relatedness, and the relationships or plant family groups can be recognised in different ways. The study of relationships is called 'taxonomy' (conventional science systems of classification) or 'ethnotaxonomy' (Indigenous systems of classification). In general, ethnotaxonomy classifies living things by their uses as food sources, whereas taxonomy names and classifies living things by the Linnaean system of genetic relatedness.

(Source: *Two Way Science – An Integrated Learning Program for Aboriginal Desert School*, p183, Commonwealth Scientific and Industrial Research Organisation, 2019)

#### **Equipment required**

- projection device
- computers, internet connection
- Student worksheets:
  - 3.1 Classifying living things
  - 3.2 Using a dichotomous key
  - 3.3 Key to soil invertebrates
  - 3.4 What's in a name?
- soil sample (from module 2) or images of soil invertebrates in a soil sample
- microscope





#### Instructions for suggested activities

- Through discussion, introduce the key ideas of classification of living things: Why classify and what are the basic principles of classification?
- Show a video clip on classification (depending on the students' level of engagement and ability). A useful clip that is pitched at an appropriate level for Year 7 students is Classification: Amoeba Sisters at <https://www.youtube.com/watch?v=DVouQRAKxYo>.
- In pairs, students work through the student worksheet 3.1 Classifying living things . •
- Introduce the use of biological (dichotomous) keys as a means of identifying an unknown species.
- Students work through the student worksheet 3.2 Using a dichotomous key. •
- Discuss with students the role of taxonomists in identifying pest species and how this identification plays an important role in maintaining biosecurity.
- Display the PowerPoint presentation Lesson 2: Insect Classification at <a href="http://www.primezone.edu.au/uploaded">http://www.primezone.edu.au/uploaded</a> files/document</a> uploads/Yr7%20Grain%20Lesson%202% 20InsectClassification.pdf>. This presentation is linked to the Primezone resource: Grain Biosecurity - Year 7: 2016 Teaching Resources - Lesson 2, NSW Govt. Dept. of Primary Industries at <a href="http://www.primezone.edu.au/uploaded">http://www.primezone.edu.au/uploaded</a> files/document</a> uploads/Yr7%20Grain%20Teacher%20R

esource.pdf >.

- Follow up the insect classification exercise with the class as a whole to improve competency of classifying insects utilising the 'What Bug is That?' insect identification key in Lesson 2, Appendix 3 of the Grain Biosecurity resource. Alternatively, an online key for identifying invertebrates is the Commonwealth Scientific and Industrial Research Organisation (CSIRO) dichotomous key at <a href="https://www.ento.csiro.au/education/key/couplet\_01.html">https://www.ento.csiro.au/education/key/couplet\_01.html</a>>.
- As a practical exercise, students can use the Student worksheet 3.3 Key to soil invertebrates to identify the invertebrates present in their soil samples collected during Activity 2. A useful website for this exercise is the CSIRO: Key to the Invertebrates at: <a href="https://www.ento.csiro.au/education/key/couplet\_01.html">https://www.ento.csiro.au/education/key/couplet\_01.html</a>>
- As an extension activity, students should attempt Student worksheet 3.4 What's in a name? Although not directly related to soils, this activity encourages students to examine the confusions which may arise when common names for species are used rather than scientific names.

# Module 4: Food chains and food webs

(Approximately 1 hour)



#### Module focus

Within the context of soil health, this module is designed for students to gain an understanding of the basic principles of biological classification present in content descriptor (ACSSU112)

#### Learning intentions

Students will be able to:

- use food chains to show feeding relationships in a habitat (such as the soil) •
- construct and interpret food webs to show relationships between organisms in the soil . environment
- classify organisms of an environment according to their position in a food chain
- recognise the role of microorganisms, such as bacteria and fungi, within soil food chains and food webs





#### Background information (relevant to both modules 4 and 5)

The place where any living thing occurs is called its 'habitat'. The habitat must provide all the basic requirements organisms need to survive. The requirements of living things can be divided into two types:

- biotic factors, which are the living factors, such as food, competition and disease
- abiotic factors, which are the non-living factors, such as water, wind, light, soil and temperature.

An ecosystem is a system formed by organisms interacting with each other and the non-living factors in a balanced way. The organisms in an ecosystem are interdependent, meaning that they rely on each other for survival.

A food chain is a simple flowchart showing the direction of flow of matter and energy. It contains producers (usually green plants which carry out the process of photosynthesis) and consumers (which must consume other organisms for their energy and nutrients). Consumers are further subdivided into herbivores, carnivores, omnivores and decomposers.

A food web is made of all the food chains in an ecosystem. Soil is a complex ecosystem that is essential to life on Earth. Soils are the principal resource for food production. They facilitate the life cycle of growth, sustenance and decay.

Usually when we think of food chains and food webs we think of plants as being at the beginning – the primary producers that carry out photosynthesis. Herbivores then consume the plants. And then various levels of carnivores and omnivores interact to complete the system. Plants, however, depend on the soil – particularly the soil ecosystem – to help them obtain water and nutrients and protect them from pathogens. Soil and plants have an inextricable relationship.

(Source: Soil Science Australia, *Soils in Food Chains – Teachers Guide* available for download at: <<u>https://www.soilscienceaustralia.org.au/training/soils-in-schools/teacher-guides/></u>)

There are billions of microorganisms in the soil, each playing a vital role in soil and plant health. The soil food web includes species of bacteria, fungi and nematodes. Soil microorganisms are responsible for most of the nutrient release from organic matter.

When microorganisms decompose organic matter, they use the carbon and nutrients in the organic matter for their own growth, and in the process release excess nutrients into the soil for plants to use.

Bacteria are single-celled organisms that are the most abundant microbes in the soil. In a gram of soil there can be billions of bacteria. The numbers of bacteria are highly dependent on changes in soil moisture, soil temperature and carbon substrate. Some bacteria are dependent on specific plant species. Bacteria help to degrade organic matter, suppress soil disease and transform nutrients inside plant roots. Other members of the soil food-web eat bacteria as a food source. Symbiotic nitrogen fixation is a significant source of nitrogen for Australian agriculture and may account for up to 80% of total nitrogen inputs. In the symbiosis, bacteria (*Rhizobia* or *Bradyrhizobia*) fix nitrogen gas from the atmosphere and make it available to various plants (eg lupins). In exchange, they receive carbon from the plant.

Soil fungi are microscopic plant-like cells that can be single-celled (eg yeast) or can grow in long thread-like structures, or hyphae, that make a mass called mycelium. Some species form symbiotic relationships with plant roots. Fungi are generally not as dependent on specific plant species as some bacteria, and populations are slower to develop. Most agricultural plants (except lupins and canola) form a symbiosis with arbuscular mycorrhizal (AM) fungi that can increase phosphorus uptake by the plant.





Nematodes are microscopic worms that are sometimes known as 'roundworms'. Soil-living nematodes are generally microscopic (less than 1 mm long and only 15–20 µm wide). Nematodes cause hundreds of millions of dollars-worth of crop losses every year. But these pest nematodes are only one component of the soil nematode community. A diverse range of beneficial free-living nematodes also occur in soil, and they play a vital role in many important soil processes.

(Source: Soilquality.org.au Fact Sheets - Soil Bacteria and Fungi, NSW; Soil Biological Fertility; The Nematode Community in Australian Grain-Growing Soils)

As soil science is an integrated science, it covers several scientific disciplines, including physics, biology, chemistry, ecology and statistics. Soil scientists don't just work with soil and in agriculture; they also examine how soil affects water, plants, animals and the atmosphere. Soil scientists can work in rural or urban areas. As science is an international endeavour, the knowledge that soil scientists discover is useful around the world. As a result, soil scientists often find themselves working in different countries throughout their careers.

(Source: Soil Science Australia – Soil Science Careers, Teachers Guide available for download at: <<u>https://www.soilscienceaustralia.org.au/training/soils-in-schools/teacher-guides/>.</u>

#### **Equipment required**

- Computers, internet connection
- Student worksheet
  - 4.1 Food chains and food webs

#### Instructions for suggested activities

- Through discussion, introduce the key ideas of the interdependence of all life on the planet through food chains and food webs and their being intrinsically involved in the cycling of key elements such as carbon. Introduce the key concept that soils are complex ecosystems.
- Watch a YouTube video on food chains and food webs such as the Fuse School *Food chains and food webs:* <u>https://www.youtube.com/watch?v=2lqhJNgn\_Wg</u>
- Direct students to make notes of the key ideas and answer questions 1 to 4 on Student worksheet 4.1. Discuss student answers.
- Introduce the concept of ecosystems being more complex usually made up of various interacting food chains forming a food web.
- Direct students to watch a YouTube video on food chains and food webs such as *Food Webs and Energy Pyramids: Bedrock and Biodiversity*: <u>https://www.youtube.com/watch?v=-oVavgmveyY</u>
- Direct students to make notes of the key ideas then answer the questions 5 to 8.
- Introduce activity 2 on the worksheet with a discussion of the soil food web diagram on page 3 discuss its key features.
- Show students *The Soil Story* at <<u>https://www.youtube.com/watch?v=nvAoZ14cP7Q</u> >- an
  engaging video that examines important connections between soil, farming and compost and the
  carbon cycle on Earth.
- To finish, direct students to answer Activity 2 questions 1 5 on the worksheet. Discuss student answers.





# (Approximately 3-4 hours)

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#### Module focus

Within the context of soil health and its impact on primary production, this module is designed for students to elaborate on their understanding of soils as dynamic ecosystems. It examines the various interactions that occur between different soil organisms in the soil food web; allows students to compare different types of ecosystems in terms of inputs, outputs and the amount of recycling of matter; and introduces students to soil ecosystems can be conserved, restored and regenerated.

#### Learning intentions

Students will be able to:

- explore how living things can cause changes to their environment and impact other living things
- investigate Aboriginal and Torres Strait Islander Australians' responses to the disruptive interactions of invasive species and their effect on important food webs that many communities are a part of, and depend on, for produce and medicine
- investigate the effect of specific human activity on local habitats, such as deforestation, agriculture or the introduction of new species
- understand that people use science understandings and skills in their occupations and these have influenced the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management

#### **Equipment required**

• Computers, internet connection

PowerPoint presentation

• 5.0 Ecosystem interactions

Student worksheets:

- 5.1 Symbiotic relationships
- 5.2 Soil disturbance effects
- 5.3 Keeping ecosystems balanced
- 5.4 How can we conserve, restore and regenerate our soils?
- 5.5 KWHL Chart
- 5.6 Ecosystems key terminology review



#### Instructions for suggested activities

- Go through slides 1 5 of the PowerPoint presentation 5.0 Ecosystem interactions with students which recap key ideas of habitats and the needs of living things, as well as soil being a complex ecosystem of interacting nutrient and energy cycles, plants, animals and microorganisms. Students make notes of the key ideas.
- View slides 5 to 16 of the PowerPoint presentation *5.0 Ecosystem interactions*. ensuring students watch the two *Soil health animations* and the video *Symbiosis: Mutualism, Commensalism and Parasitism* on slides 6, 9 and 10.
- Students create a summary in the table on *Student worksheet 5.1 Symbiotic relationships* of the three major types of symbiotic relationships (mutualism, commensalism, and parasitism) that occur in soil and in other ecosystems
- In the next lesson, introduce students to slides 17 of the PowerPoint presentation which asks the question *What happens to a healthy soil if it is disturbed?* Have students do a think/pair/share of their ideas.
- Show students the Soil health animation: Soil disturbance effects on slide 18 of the PowerPoint.
- In small groups have students discuss their ideas on: What types of natural and human activities could cause soils to be disrupted? What effects are likely to occur to soil food chains and food webs if soil is disturbed?
- Students record their responses in the table on *Student worksheet 5.2 What happens when our soils are disrupted by human activity?*
- Issue students with *Student worksheet 5.3 Keeping ecosystems balanced* and have students read the background information on page 1.
- Initiate a class discussion on how we could improve the health of our soils. Direct students to the AgriWebb article *How can we improve the health of our soil?* <<u>https://www.agriwebb.com/au/how-to-improve-soil-health/></u> to discover ways to restore and maintain a balanced soil ecosystem.
- After reading the article students complete questions 1 to 7 on the worksheet.
- Initiate a class discussion on how prior to European settlement, Aboriginal and Torres Strait
  islander peoples were able to maintain a balanced ecosystem by applying their knowledge of the
  country where they had lived for tens of thousands of years. Have students follow the links below to
  discover more about how feral animals and invasive plants are being managed by Aboriginal people
  to keep ecosystems in balance.
- 1. Indigenous hunters have positive impacts on food webs in desert Australia:

https://www.sciencedaily.com/releases/2019/02/190217142522.htm

2. Indigenous people and invasive species:

https://ipm.ifas.ufl.edu/pdfs/ens\_et\_al\_2015\_indigenous\_people\_and\_invasive\_species\_iucn\_c em\_ecosystems\_and\_invasiv.pdf



- As an extension exercise have students choose a feral animal or invasive plant species that is contributing to an ecosystem becoming unbalanced. Describe how the actions of Aboriginal people could help to rebalance the ecosystem.
- Form students into discussion groups of 3 4 students and introduce the question "how do we conserve, restore and regenerate our soils?"
- Give out worksheets 5.4 and 5.5
- In small groups allow students to discuss and record on the KWHL chart what they already know, what they would like to find out, and how they will go about finding out.
- As a whole class watch the Soil health animation: What are the options for managing soil organisms? (slide 19 of PowerPoint 5.0 Ecosystem interactions)
- Students complete the final column of their KWHL chart
- As extension activities if time permits students can attempt: Activity 2 What's happening in Western Australia? Activity 3 Presenting your ideas
- As a review of some of the key ideas of this module students should work back through the PowerPoint presentation 5.0 Ecosystem interactions and watch the video Understanding ecosystems for kids: producers, consumers and decomposers on YouTube: <u>https://youtu.be/bJEToQ49Yjc.</u> Make notes of the key ideas then use the following list of key terms to match the definitions in the appropriate positions on the word grid on Student worksheet 5.6 Ecosystems key terminology review.



#### **Module focus**

This module is a student self-assessment focusing on key learning from this series of activities. Students create a flowchart and a concept map.

For students:

Student worksheet:
 6.1 Self-assessment: What have I learnt? (Printed in A3 size)

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# Suggested answers to student worksheets

# Soil – the basis of food production

# Student worksheet 1.2 – Glossary activity

Key term	Etymology (origin)	Definition						
Abiotic	Greek a (without) bios (life)	Non-living chemical and physical parts of the environment that affect living organisms and the functioning of ecosystems						
Agriculture	Latin: <i>ager</i> (field), <i>cultiva</i> (growing)	The science and art of cultivating plants and livestock						
Bacteria	Latin: <i>bacterium</i> (staff, cane)	Types of prokaryotic biological cells (Simple cells without a distinct nucleus or organelles)						
Biodiversity	Greek: <i>bios</i> (life), Latin: <i>diversitas</i> (variety)	Diversity among and within plant and animal species in a given environment						
Biotic	Greek: <i>bios</i> (life)	Any living component that affects another organism and the functioning of ecosystems						
Community	Latin: <i>communis</i> (public spirit)	An assemblage of various organisms living in the same environment						
Decomposers	Old French: (opposite of put together)	Any organism that breaks down decomposing bits of organic matter						
Ecosystem	Greek: <i>oikos</i> (home), <i>systema</i> (system)	The total of interacting organisms and non-living things in a specific environment						
Food web	Old English: (fodder) (weave)	A set of interconnected food chains by which energy and nutrients circulate within an ecosystem.						
Fungi	Latin/Greek: <i>spongos</i> (sponge)	Along with bacteria, fungi are the major decomposers in most terrestrial (and some aquatic) ecosystems and therefore play a crucial role in the nutrient cycle						
Habitat	Latin: <i>habitare</i> (to dwell)	A specific ecological area that is inhabited by specific plant and animal species						
Interact	Latin: <i>inter</i> (between), <i>ago</i> (to act)	In a biological sense: organisms that act in such a way as to have an effect on each other						
Invertebrate	Latin: <i>in</i> (not), <i>vertebra</i> (joint)	Animals that are not classed as vertebrates						
Macroscopic	Greek: <i>macr</i> o (large), <i>skopos</i> (see)	Organisms that can be viewed without the aid of a microscope						
Microscopic	Latin: <i>micro</i> (minute size), <i>skopos</i> (see)	Organisms that require a microscope to be viewed						
Parasites	Greek: <i>parasitos</i> (grain, food)	Any organism that depends for its survival on a symbiotic relationship with another organism, its host which it does not usually kill directly but does negatively affect.						
Predators	Latin: <i>praedator</i> (plunderer)	Organisms that live by killing and consuming other living organisms						
Saprophytes	Greek: <i>sapros</i> (rotten, putrid), <i>trophe</i> (nourishment)	Soil fungi and bacteria involved in the processing of decayed organic matter.						

(Source: Wikipedia: Glossary of ecology available online at: https://en.wikipedia.org/wiki/Glossary of ecology)



# Student worksheet 1.2 – Extension questions

- 1. Biodiversity is essential to maintain a healthy ecosystem
- 2. Over time, soil microbes and plant roots create a complex ecosystem that attracts other living organisms such as nematodes and earthworms. This complex food web helps plants to thrive, breaks down dead organic matter and recycles nutrients back into the environment
- 3. Predator nematodes feed on other nematodes. They also eat bacteria, fungi and small singlecelled organisms (protozoa). The digested pests are then added to the soil organic matter
- 4. Parasitic nematodes cause problems in agricultural production because they feed on plant roots and slow down plant growth
- 5. Saprophytic nematodes are also known as decomposers because they break down organic matter in the soil; release nutrients for plant use; and improve soil structure, water-holding capacity and drainage
- 6. The soil biome is important for a variety of reasons, including cycling of ecosystem nutrients; plant growth and nutrition; entry and storage of water in soil; resistance to erosion; suppression of pests, parasites and disease; capture of carbon; gas-exchange cycles; and breaking down of organic matter
- 7. Bacteria, fungi, protozoa, nematodes
- 8. Answers may include: maintain healthy ecosystems, improve agricultural production, recycle nutrients and gases
- 9. Ploughing destroys larger microorganisms, leading to system unbalance and breakdown; chemical pesticides and herbicides kill both harmful and useful organisms, leading to an unbalanced ecosystem

## Student worksheet 3.1 – Classifying living things

#### Group discussion activity 1

2.	Cattle – Bos Taurus	Pigs – Sus scrofa
	Chickens – Gallus gallus domesticus	Sheep dogs – <i>Canis Iupis</i>
	Sheep – Ovis aries	Horses – Equus caballus

Goats – *Capra aegagrus* vary but may include discussion of the sheep dog – dogs have recently been reclassified as in the same species as the wolf

#### **Group discussion activity 2**

Jarrah and karri are most closely related as they are in the same genus – *Eucalyptus,* whereas marri is in a different genus – *Corymbia.* 

#### **Group discussion activity 3**

2. Taxonomists would be involved in identifying which species are susceptible to *Phytophthora*. They would identify the pathogen as being *Phytophthora*. They would also identify other soil species



#### Group discussion activity 4

- 2. Similarities both systems identify and order living things; both systems are hierarchical. Differences – Aboriginal classification systems relate more to purpose (such as food, medicine), whereas western classification systems are based more on structure and genetics
- 3. Answers may vary but should refer to both systems being important to maintaining ecosystem stability and biodiversity

#### Student worksheet 3.2 – Using a dichotomous key

Insect pest	Scientific name	Insect order (identified from dichotomous key)	Clues used to identify insect pest					
			1b Insect has two pairs of wings					
Red imported	Solenopsis	Wasps, bees and ants	3b Front wings do not form rigid cover over hind wings					
fire ant	invicta	Hymenoptera	7b Wings clear like a membrane					
			9b Front and hind wings different size; body has a narrow 'waist'					
Queensland fruit		Flies	1a Insect has one pair of wings					
fly	Bactrocera tryoni	Diptera	Clues used to identify insect pest b Insect has two pairs of wings b Front wings do not form rigid cover over hind ings b Wings clear like a membrane b Front and hind wings different size; body has a arrow 'waist' a Insect has one pair of wings a Hind wings reduced to tiny knobs b Insect has two pairs of wings a Front wings rigid to form a protective cover for lear hind wings reduced to tiny knobs b Ungs rigid and meet in straight line down the ack a Insect has two pairs of wings b Insect has two pairs of wings b Ungs rigid and meet in straight line down the ack b Insect has two pairs of wings b Front wings rigid to form a protective cover for ear hind wings a Sucking mouthparts that look like a beak b Insect has two pairs of wings a Front wings rigid to form a protective cover for ear hind wings co Chewing mouthparts a Wings not rigid a Head free and exposed ront legs without strong spines for grasping; hind gs long and slender b Insect has two pairs of wings a Front wings rigid to form a protective cover for ear hind wings b Chewing mouthparts b Chewing mouthparts b Wings not rigid b Chewing mouthparts b Chewing mouthparts b Wings ingid to form a protective cover for ear hind wings b Chewing mouthparts b Chewing mouthpa					
			1b Insect has two pairs of wings					
Khanra haatla	Trogoderma	Beetle	3a Front wings rigid to form a protective cover for clear hind wings					
Khapia beelle	granarium	Coleoptera	4b Chewing mouthparts					
			5b Wings rigid and meet in straight line down the back					
Stable fly	Stomyxos calcitrans	<b>Flies</b> Diptera	1a Insect has one pair of wings 2a Hind wings reduced to tiny knobs					
European wasp	Vespula	Wasps, bees and ants	1b Insect has two pairs of wings					
	germanica	Hymenoptera	3b Front wings do not form rigid cover over hind wings					
			7b Wings clear like a membrane					
			9b Front and hind wings different size; body has a narrow 'waist'					
Aphids	Sitobion avenae	<b>True bugs</b> Hemiptera	1b Insect has two pairs of wings 3b Front wings rigid to form a protective cover for clear hind wings 4a Sucking mouthparts that look like a beak					
Spur-throated	Austracris	Grasshoppers and crickets	1b Insect has two pairs of wings					
IOCUSIS	guttulosa	Orthoptera	3a Front wings rigid to form a protective cover for clear hind wings					
			4b Chewing mouthparts					
			5a Wings not rigid 6a Head free and exposed Front legs without strong spines for grasping; hind legs long and slender					
Small hive Aethina tumida		Beetle Coleoptera	1b Insect has two pairs of wings					
20040		e su spiola	3a Front wings rigid to form a protective cover for clear hind wings					
			4b Chewing mouthparts					
			5b Wings rigid and meet in straight line down the back					



# Student worksheet 3.2 (continued)

- 1. Student answers may vary but may include difficulties with viewing insect body parts from different angles.
- 2. Student answers may vary but may include suggestions of viewing insect body parts from different angles and viewing live specimens.
- 3. Correct identification of pests is important to ensure biosecurity and to ensure that beneficial insects are not targeted incorrectly.
- 4. Insect damage leads to a loss of agricultural productivity. To achieve the same yield, more land must be used.
- 5. Biosecurity is the protection of the economy, environment and community from the negative impacts of pests and diseases. Australia has unique ecosystems and flora and fauna that are found nowhere else in the world. It is critical for Australia's biodiversity that we protect our natural resources.
- 6. Key biosecurity goals include:
- preventing the entry of new pests and diseases into Australia (or into a new state or region)
- quickly finding, containing and eradicating, where possible, new outbreaks before they spread
- managing established pests and diseases to achieve eradication where possible or at least minimise the harm they cause to industry and the environment
- ensuring that industry is equipped with appropriate surveillance, response and management strategies to respond to biosecurity threats and helping to facilitate Australia's current global market access
- continuously reviewing and improving Australia's biosecurity mitigation measures, particularly as new information comes to light.

(Source: Year 7 Grain biosecurity: 2016 teaching resources secondary schools available at: http://www.primezone.edu.au/uploaded\_files/document\_uploads/Yr7%20Grain%20Teacher%20Resource.pdf)

#### Student worksheet 3.3 – Key to soil invertebrates

- 1. Student answers may vary but may include difficulties with viewing insect body parts from different angles.
- 3. Student answers will vary; however, the statement needs to link independent variable (location of soil sample) with dependent variable (abundance and diversity of soil invertebrates).

#### Student worksheet 4.1 – Food chains and food webs

#### Activity 1: Food chains and food webs

- 1. The sun is the source of energy for green plants to manufacture their food through the process of photosynthesis.
- 2. A producer organism carries out the process of photosynthesis, thus manufacturing the original organic material for the rest of the food chain.
- 3. Arrows represent the direction of flow of matter and energy in a food chain.
- 4. Humans fit in as apex predators.
- 5. Autotroph organism that produces its own food (usually by the process of photosynthesis). Heterotroph – organism that must obtain food from other organisms
- 6. Remaining 90% is lost by various means (e.g. heat).
- 7. A food web can be described as interconnected food chains within an ecosystem
- 8. A healthy food web means there will be greater variety of organisms within an ecosystem and the ecosystem will remain relatively stable.





#### Activity 2: The soil food web

- 1. Soil organic matter.
- Answers will vary. One example: Soil organic matter → fungi → nematodes → nematodes(predators) → Arthropods → Birds
- 3. Birds and animals.
- 4. Birds may eventually decrease in numbers due to reduced food supply (reduced arthropods).
- 5. Answers may vary, but most students will conclude that humans are apex predators. Direct discussion towards developing student's understanding that humans are involved in managing the soil ecosystem.
- 6. Healthy soils are important for a variety of reasons, which include maximising the opportunity for sustainable agricultural production.

# Student activity 5.1: Symbiotic relationships

Type of relationship	Description of relationship	Examples of relationship
Mutualism	A form of symbiosis from which both individual organisms involved derive a <u>fitness</u> benefit.	Various including: Rhizobium and legume
Commensalism	A symbiotic relationship between two organisms of different species, in which one of the organisms benefits while the other remains unaffected.	Various including: Sheep dog and human
Parasitism	A <u>symbiotic</u> relationship with another organism, its <u>host</u> which does not usually kill directly but does negatively affect.	Various including: Parasitic soil nematodes, gastrointestinal worms in sheep

(Source: Wikipedia: Glossary of ecology available online at: https://en.wikipedia.org/wiki/Glossary of ecology)

# Student activity 5.2 – What happens when our soils are disrupted by human activity?

What types of natural and human activities could cause soils to be disrupted?	What effects are likely to occur to soil food chains and food webs if soil is disturbed?
Natural Leaf fall, drought, fire, flood, large animal diggings, plant community succession, tree-fall, water/wind erosion Human activities Land management practices: fertiliser use, herbicide and pesticide use, compost application, prescribed burning, cultivation, revegetation, crop rotation, harvesting, vehicle traffic Industrial or urban disturbances: acid rain, construction, disposal of household waste, toxic waste, mining, sewage release	Responses of living things in food chains depend on how the environment has changed and the tolerance limits of organisms. The availability of soil organic matter overrides the function of most soil organisms. Therefore soil disturbances that change the soil organic matter are most important.



#### Student worksheet 5.3 – Keeping ecosystems balanced

#### Activity 1: How can we improve the health of our soils?

- 1. Increased organic matter, such as manure and compost.
- 2. It improves soil structure and drainage, holds moisture and provides nutrients to the soil.
- 3. Planting a variety of different plant species.
- 4. Crops with tap roots can ease compaction, while fibrous roots add stability. Species that host beneficial fungi increase its presence in the soil, while legumes add nitrogen.
- 5. Earthworms may be harmed by pesticides. Earthworms increase nutrient availability, improve drainage and create a more stable soil.
- 6. Nitrogen is important for protein production in crops. Too much nitrogen can make soil acidic and slow plant growth.
- 7. Controlling water flow increases the filtration of water and minimises the soil erosion that might occur

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#### Student worksheet 5.6 – Ecosystems key terminology review