PRIMED

Teacher resource

Year 9

Science

GOVERNMENT OF WESTERN AUSTRALIA

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

Teaching guide: Ecosystems and balance – producing, protecting and conserving

Resources overview

PRIMED mission

To increase student understanding of agriculture, fisheries, fibre, forestry and food (primary industries) careers to enable Year 7–10 students to make informed career-pathway choices.

About the resource set

This series of activities challenges students to engage with the *Western Australian Science Curriculum* by focusing on balanced and sustainable ecosystems in Western Australian food and fibre production primary industries.

Through this process, students can gain a deeper understanding of the complexities of the biological and physical world, and how we interact with it to sustainably produce essential food and fibre.

Curriculum links

This resource set is designed to be a learning pathway for Year 9 science students to develop their understanding of the *Western Australian Curriculum* **Biological Sciences** content descriptions:

- Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

It also engages students with the **Science as a human endeavour** content descriptions:

- Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE158)
- People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160)

It further allows development of the **Science inquiry skills** integral to the *Western Australian Science Curriculum*.

Resource set structure

The resource set is structured around constructivist learning principles using the 5E model: engage, explore, explain, elaborate and evaluate.

With this approach:

1. Students' interest and minds are **engaged** in thinking about sustainable natural ecosystems and how agricultural ecosystems compare. Using the context of WA primary production, they examine interactions between organisms such as predator/prey, competitors and disease.
2. Using examples from WA primary production, students **explore** various biotic and abiotic factors that affect organisms in agricultural ecosystems such as:
    - how population planting density affects growth of crops
    - factors affecting photosynthesis
    - the symbiotic effects of plant inoculants on growth
    - how various WA plants are adapted to fire.
3. Students **explain** how energy flows into and out of an ecosystem via the pathways of food webs. Using various agricultural contexts (piggery, chicken meat farm, aquaculture), students compare the cycling of matter and flow of energy and how it must be replaced to maintain the sustainability of the system when compared with a natural ecosystem.
4. Students **elaborate** on their understanding by examining a range of scientific case study activities that showcase a variety of specific or 'wicked' problems facing WA primary producers:
    - Phytophthora dieback
    - Biosecurity (the Queensland fruit fly)
    - Rumen microbes and the role of methane gas emissions contributing to climate change
    - Dung beetles and bush flies
5. Students **evaluate** their understanding of the key learning outcomes.

Educational process	Teaching and learning focus	Resources
Engage Engage students and elicit prior knowledge	**Module 1: Introduction to sustainable ecosystems (3 hours)** Students: • recall key terminology needed to understand the various biotic and abiotic factors and interactions that affect natural and agricultural ecosystems • within the context of WA primary production, examine various interactions that occur within ecosystems such as predator/prey, parasites, competitors, pollinators (including wind), symbiotic relationships and disease Students will use interactive strategies and develop research skills to further elicit understanding.	PowerPoint presentation: • 1.0 Sustainable ecosystem interactions Student worksheets: • 1.1 Silent card shuffle • 1.2 Ecological interactions • 1.3 Student research links
Explore Provide hands-on experience of the phenomenon, develop scientific explanations for observations and represent developing conceptual understanding	**Module 2: Exploring ecosystem interactions (4 hours)** Teachers choose from a range of practical, inquiry-based investigations designed to examine a range of biotic and abiotic factors affecting agricultural and natural ecosystems: • effects of population density on plant growth rates (biotic – intraspecific competition) • factors affecting photosynthesis (abiotic – eg temperature, light, soil type) • effects of arbuscular mycorrhiza inoculum on plant growth (biotic – symbiosis) • adaptations of WA plants to fire (abiotic – heat and smoke)	Student investigations/worksheets: • 2.1 Give me space! How plant population density affects growth • 2.2 Factors affecting photosynthesis • 2.3 Effects of arbuscular mycorrhiza inoculum on plant growth • 2.4 I'm on fire! Investigating Western Australian plant adaptations to fire • 2.5 Group investigation framework
Explain Develop scientific explanations for observations and represent developing conceptual understanding. Consider current scientific explanations	**Module 3: Maintaining ecosystem balance and sustainability (3 hours)** Students explain: • how energy flows into and out of an ecosystem via the pathways of food webs • using various agricultural contexts, students explore the cycling of matter and flow of energy and how it must be replaced to maintain the sustainability of the system when compared with a natural ecosystem	PowerPoint presentation: • 3.0 Matter and energy in ecosystems Student worksheets: • 3.1 Energy flow in agricultural ecosystems • 3.2 Marine food webs in WA • 3.3 Aquaculture in WA

Elaborate Extend understanding to new contexts or make connections to additional concepts through student-planned investigation	**Module 4: Case studies in sustainable ecosystem management (8 hours)** Students elaborate on their understanding by examining a range of scientific case study activities that showcase a variety of specific or 'wicked' problems facing WA primary producers: • Phytophthora dieback • Biosecurity (the Queensland fruit fly) • Rumen microbes and the role of methane gas emissions contributing to climate change • Dung beetles and bush flies	Student worksheets: • 4.1 Case study 1: Phytophthora dieback • 4.2 Case study 2: Queensland fruit fly (Qfly) • 4.3.1 Case study 3: Rumen microbes and methane gas emissions • 4.3.2 Cooperative learning jigsaw template • 4.4 Case study 4: The dung beetle story
Evaluate Students demonstrate their understanding and reflect on their learning journey, and teachers collect evidence about the achievement of outcomes	**Module 5: What have I learnt? (2 hours)** This module is a student cooperative learning jigsaw focusing on key concepts from this learning sequence. It consists of students in a cooperative learning small group situation reviewing one key topic in depth and teaching other students in the class their knowledge. The opportunity is also provided for students to assess other students in a peer review.	Student worksheets: • 5.1 What have I learnt? • 5.2 Cooperative learning jigsaw template • 5.3 Peer review template

Learning resources and sequence

Module 1: Introduction to sustainable ecosystems (3 hours)

ENGAGE → EXPLORE → EXPLAIN → ELABORATE → EVALUATE

Learning intentions

Students will be able to:

- recall and apply key terminology applicable to understanding the biotic and abiotic factors that influence sustainable ecosystems
- understand various interactions that occur within ecosystems such as predator/prey, parasites, competitors, pollinators (including wind), symbiotic relationships and disease
- develop research skills
- apply their understanding of ecosystems to primary industries in WA.

Resources and equipment

- PowerPoint projection facility

PowerPoint presentation:

- 1.0 Sustainable ecosystem interactions

Student worksheets:

- 1.1 Silent card shuffle
- 1.2 Ecological interactions
- 1.3 Student research links

Instructions for suggested activities

Prior knowledge - from studying year 7 science students should have:

- a basic understanding of using food chains and food webs to show relationships that occur between organisms in an environment
- investigated the role of microorganisms within food chains and food webs
- investigated the effect of human activities on local habitats

Lesson 1

1. Introduce students to the idea that key terminology is required to understand the various interactions occurring within ecosystems. In a class discussion, brainstorm key terms that students would associate with ecosystems
2. Divide students into small groups. Explain the basic steps of a silent card shuffle activity (display slides 2 and 3 from PowerPoint 1.0)
3. Display slide 4 ‘Western Australian ecosystems’ from PowerPoint 1.0. Discuss with students the definition of a natural ecosystem and how this compares with an artificial agricultural ecosystem
4. Distribute Student worksheet 1.2 and direct students to read the background information on the biotic and abiotic factors that influence ecosystems. At the same time, display PowerPoint 1.0 slide 5 ‘Factors affecting ecosystems’
5. Begin Activity 1. Direct students to watch the video FuseSchool – Interactions within an ecosystem (also on slide 6 of PowerPoint)
6. Students create an infographic of the abiotic and biotic factors interacting in the life of a sheep on a sheep station. If students are unfamiliar with how to create an infographic, a useful resource is Creative Educator - Infographics

7. Display PowerPoint 1.0 slide 7 'Community relationships'
   Students watch the videos Ecological Relationships – Competition – Predator and Prey - Symbiosis and Symbiosis: Mutualism, Commensalism and Parasitism
8. After watching the videos, students create a summary of ecological relationships within a community using the sub-headings **Competition**, **Predator and Prey**, and **Symbiosis**

Lesson 2

1. Begin lesson 2 with a recap of key ideas from lesson 1
2. As a follow-up activity, students do Student worksheet 1.2 Activity 2 'Symbiosis – an important biotic factor', which focuses on the important relationship between pasture legumes forming a symbiotic (mutually beneficial) association with specific soil bacteria (rhizobia) to meet their nitrogen requirements
3. Students:
   - watch the video Legumes: Biological nitrogen fixation
   - follow the link Lupin in Western Australian farming and read the article. As this article requires quite an advanced reading level, teachers may need to scaffold this activity or create a simplified version depending upon the ability level of their students.
   - answer the question of how they think WA primary producers are taking advantage of this symbiotic relationship
4. Display PowerPoint 1.0 slide 8 'Sustainable agricultural ecosystems'. Discuss that because agricultural ecosystems are artificial, various factors need to be carefully managed if they are to remain productive, profitable, viable in the long term, and ecologically sustainable. Primary producers must therefore understand the complex biotic and abiotic factors and relationships occurring within their agricultural ecosystems
5. Have students work through and take notes on slides 9 to 14 of PowerPoint 1.0, which examine various factors needing to be managed. These include:
   - pests, weeds and disease
   - predators and competitors
   - habitat (eg soil, water, pasture quality, erosion, salinity)

Lesson 3

In lesson 3, students choose one of the following topics to research (PowerPoint slide 15). They negotiate with their teacher how they will present their research.

- Integrated Pest Management
- Biosecurity in WA
- Control of invasive weeds (eg blackberry, Patterson's curse)
- Disease management in WA forestry
- Disease management in WA fisheries
- Maintaining soil health
- Management of fire regimes in WA
- Salinity management in WA
- Feral animal control in WA
- Endangered species in WA

Suggested links to assist student research are provided in Student worksheet 1.3.

Module 2: Exploring ecosystem interactions (4 hours)

ENGAGE → **EXPLORE** → EXPLAIN → ELABORATE → EVALUATE

Learning intentions

In this module, students are challenged to design and conduct a science investigation into biotic or abiotic factors affecting plant growth. Four different investigations are provided. The investigations allow students to collaboratively demonstrate their understanding of the *Western Australian Science Curriculum* inquiry skills content descriptors. Teachers will need to be flexible and tailor the investigation to suit the ability level of their students and the amount of time available.

Through this process students will be able to:

- Formulate questions or hypotheses that can be investigated scientifically (ACSIS164)
- Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS165)
- Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (ACSIS166)
- Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS169)
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)
- Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS171)

Resources and equipment

Student investigation/worksheets:

- 2.1 Give me space! How plant population density affects growth
- 2.2 Factors affecting photosynthesis
- 2.3 Effects of arbuscular mycorrhiza inoculum on plant growth
- 2.4 I'm on fire! Investigating Western Australian plant adaptations to fire
- 2.5 Group investigation framework

A list of equipment specific to each investigation is supplied on each of the student worksheets.

Notes for teachers/laboratory staff

- Student investigation 2.3 – a number of different types of seeds can be used including lucerne, alfalfa, clover, lupin, soybean, cowpea and mung bean. Seeds and inoculant can be purchased from agricultural suppliers. A link showing how to prepare and apply inoculant is located at: Using Mycorrhizae in your garden – with instructional video
- Student investigation 2.4 - useful information on the use of smoke to stimulate germination of Australian plants can be found at Government of Western Australia, Botanic Gardens and Parks Authority. This website contains a slideshow illustrating how to make smoke water. Pre-prepared smoke water can also be purchased online.

Instructions for suggested activities

Teachers will need to choose the investigation(s) most suited to their particular school situation. Each investigation is designed to take approximately four hours of class time. Student worksheet 2.5 is designed to assist students to go through the necessary steps of an investigation. Teachers may, however, choose not to use this resource if they consider that their students do not require this level of scaffolding.

A typical four lesson sequence may be:

Lesson 1 – Planning the investigation

Lesson 2 – Setting up the experimental procedure

Lesson 3 – Collecting and analysing the experimental data

Lesson 4 – Evaluating and communicating the experiment

Module 3: Maintaining ecosystem balance and sustainability (3 hours)

ENGAGE → EXPLORE → **EXPLAIN** → ELABORATE → EVALUATE

Learning intentions

In this module, students explore how energy flows into and out of a natural ecosystem via the pathways of food webs. Using various agricultural contexts, students are challenged to explain how the cycling of matter and flow of energy within an agricultural ecosystem such as a piggery or chicken meat farm must be constantly monitored and replaced to maintain the sustainability of the system when compared with a natural ecosystem.

Resources and equipment

PowerPoint presentation:

- 3.0 Matter and energy in ecosystems

Student worksheets:

- 3.1 Energy flow in agricultural ecosystems
- 3.2 Marine food webs in WA
- 3.3 Aquaculture in WA

Instructions for suggested activities

Lesson 1

Using slides 2 and 3 of PowerPoint 3.0, introduce the concept of how natural ecosystems are usually sustainable and therefore have the ability to maintain suitable living conditions for the community of organisms within the ecosystem. For these ecosystems to be sustainable, there must be all of the necessary elements for survival and growth (such as carbon, nitrogen, hydrogen, oxygen). Energy into the ecosystem is usually in the form of sunlight. Nutrient elements are recycled and there is considerable biodiversity.

Discuss how major agricultural ecosystems in WA (such as wheat, cattle, fisheries, forestry) can also be sustainable. For this to occur, these ecosystems require a regular supply of inputs of both matter and energy, as a significant proportion of biomass is removed from the system as agricultural produce. Agricultural ecosystems must therefore be carefully managed.

Distribute Student worksheet 3.1 and allow students sufficient time to read the background information. Using PowerPoint slides 4 and 5, introduce the key terminology and concepts of producers, consumers, autotrophs, heterotrophs, food chains and food webs.

Introduce students to Activity 1: Energy use in a piggery. Discuss with students the various energy needs of a piggery and the different methods used to farm pigs in Australia. Have students follow the link Production cycle – Aussie Pig Farmers and read about the pig production cycle and watch the two videos *Story of Pork: Breeding* and *Story of Pork: Growing* on this site. Students summarise their ideas on the worksheet.

In the second part of Activity 1, students examine the total energy use of four different Australian piggeries. Students use the data to identify the major energy usage across the piggeries and suggest some possible ways that energy use in the piggeries might be made more efficient and sustainable.

Introduce students to Activity 2: Energy use in a chicken farm. Discuss with students how a chicken farm can be described as a closed system – the inputs and outputs are carefully managed. The closed system of a chicken meat farm can be thought of as a simple system that models the interactions, flow of energy and the cycling of matter through a natural ecosystem. Direct students to follow the link: Chicken farming in the living world and watch the video *Chicken farming in the real world*. Students take notes of the key ideas in the video. Encourage students to use the important scientific language (such as biotic, abiotic). After watching the video and taking notes, students answer the questions on the worksheet.

As an extension activity, students may like to explore the associate careers of veterinarians and animal nutritionists at Veterinarians and animal (pig) nutritionists.

Lesson 2

Begin lesson 2 with a recap of the ideas of food chains and food webs using slides 5 and 6 of PowerPoint 3.0. Show the video Food chains and food webs.

Discuss with students how food chains and food webs are all components of larger biogeochemical cycles such as the carbon cycle. Show and discuss with students PowerPoint 3.0 slide 7 illustrating the carbon cycle.

Distribute Student worksheet 3.2 and begin Activity 1 by discussing with students the importance of WA's wild-catch seafood industry and its sustainable management by Department of Primary Industries and Regional Development (DPIRD) - Fisheries.

Examine the types of organisms and interactions that would be present in a marine food web off the WA coast. Allow students time to visit at least one of the following WA marine food webs from the Marine Waters resources (PowerPoint 3.0 Slide 9):

Cocos Islands Food Web

Christmas Islands Food Web

South Coast Food Web

Allow students time to do the questions on Student worksheet 3.2. Discuss with students the concept of a food pyramid (PowerPoint 3.0 slide 10) and how only around 10% of energy is available to the next trophic level as much energy is lost during the transfer process. Direct students to Activity 2 where they examine one species on the South Coast food web in more detail. Students follow the link Fisheries fact sheet – pink snapper and read the information on the pink snapper. In the space below, they describe how an extensive knowledge of the biology of an important species like the pink snapper is essential if the species is to be fished sustainably as well as the ecosystem remaining in balance.

As an extension activity, students can follow the link Careers in fisheries to explore careers in fisheries management.

Lesson 3

Introduce lesson 3 by recapping the previous lesson on food chains and food webs in the WA wild-catch seafood industry. Pose the question to students of whether they think we should be encouraging more farming of seafood species (aquaculture) in WA.

Distribute Student worksheet 3.3 Students begin Activity 1 by following the link Fact sheet: Aquaculture in Western Australia and completing the table on the worksheet. Discuss the students' findings.

Begin Activity 2 by following the link Barramundi (aquaculture) | AgriFutures Australia and watching the video Investigating Australian approaches to producing fish, seafood and meat.

Discuss with students how aquaculture of a species such as barramundi is an example of a food production system that has the potential to improve the long-term health of populations, ecosystems and environmental quality.

Students use the information gathered to create a poster or brochure on aquaculture of barramundi in WA.

As an extension activity, direct students to PowerPoint slide 11 where students can follow the links Deadly story and Indigenous hunters vital to robust food webs in Australia to examine the traditional management of food webs by Aboriginal and Torres Strait Islander peoples.

Module 4: Case studies in sustainable ecosystem management (8 hours)

ENGAGE → EXPLORE → EXPLAIN → ELABORATE → EVALUATE

Learning intentions

In this module, students elaborate on their understanding by examining a range of scientific case study activities that showcase a variety of specific or 'wicked' problems. A wicked problem is a term first introduced by Rittel and Webber in 1973 to describe a complex problem which avoids straightforward articulation and is impossible to solve in a way that is simple or final. Climate change is a classic example of a wicked problem.

(Source: Stoney Brook University, 2021, 'What is a wicked problem?' accessed 28 June 2021).

In this series of case studies, students examine four different wicked problems facing WA primary producers. These are:

- Phytophthora dieback
- Biosecurity (the Queensland fruit fly)
- Rumen microbes and the role of methane gas emissions contributing to climate change
- Dung beetles and bush flies

Resources and equipment

Computer
Internet connection

Student worksheets:

- 4.1 Case study 1: Phytophthora dieback
- 4.2 Case study 2: Queensland fruit fly (Qfly)
- 4.3.1 Case study 3: Rumen microbes and methane gas emissions
- 4.3.2 Cooperative learning jigsaw template
- 4.4 Case study 4: The dung beetle story

Instructions for suggested activities

Each of the four case studies is designed to be self-guided and take students around two hours to complete. Students will require access to computers and internet.

Each case study is structured in a similar manner (except for 4.3 Rumen microbes and methane gas emissions, which has a cooperative learning jigsaw included):

1. Background information on the particular wicked problem is presented to students
2. The wicked problem is defined
3. Student activity 1: students research to find out more on the impacts of the wicked problem in WA
4. Student activity 2: students examine aspects of the biology of the species involved (for example, life cycle and growth) and how these could be related to the wicked problem
5. Student activity 3: students examine possible science and technology solutions to the wicked problem
6. Student activity 4: students examine careers that may be involved in tackling the wicked problem
7. Student activity 5: numeracy or literacy activities designed to build either data analysis or literacy skills

Module 5: What have I learnt? (2 hours)

ENGAGE → EXPLORE → EXPLAIN → ELABORATE → EVALUATE

Learning intentions

This module is a small group activity where students review key information on a topic they have learnt during this series of modules on sustainable ecosystems and present their findings to other members of their group in the form of an expo. Student presentations need to be 'stand-alone' in the form of a poster, brochure, or PowerPoint slideshow.

The opportunity is also provided for students to assess other students in a peer review.

Resources and equipment

Student worksheets:

- 5.1 What have I learnt?
- 5.2 Cooperative learning jigsaw template (enlarged to A3)
- 5.3 Peer review template

Instructions for suggested activities

This activity is a group activity where small groups review key information that they have learnt during this series of modules on sustainable ecosystems. The object is for students to teach and learn from other students. This type of activity is called a jigsaw.

Students first need be allocated to a "home group" of up to six students (depending on the number of students in the class). Each member of the home group is given a number (1 – 6).

Next, re-form the students into new "expert groups" by finding other students in the class with the same number. Each expert group is assigned one of the topics on Student worksheet 5.1 to become an "expert" on. How students find out their information present it to others is variable. It is recommended that students are given an A3 sized copy of Student worksheet 5.2.

Allow students a maximum of 50 minutes. During this time, they will need to access the various Student worksheets, PowerPoint presentations, internet links, videos provided in the resource, as well as textbook or other information.

At the end of the 50 minutes, re-form the original home groups. In the next class period, the home group task is to cycle amongst the presentations and complete the *Cooperative learning jigsaw template 2* document as a summary. An opportunity for peer assessment is also provided (Student worksheet 5.3).

Acknowledgements

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Suggested answers to student worksheets

Ecosystems and balance – producing, protecting and conserving

Student worksheet 1.1 – Silent card shuffle

Terms	**Definitions**
Ecology	A branch within biology that deals with the relationships of organisms to one another and to their physical surroundings
Environment	The natural world, as a whole or in a particular geographical area, especially as affected by human activity
Habitat	The natural home or environment of an animal, plant, or other organism
Natural ecosystem	A biological community of interacting organisms and their physical environment
Agricultural ecosystem	An artificial biological community (related to agriculture) of interacting organisms and their physical environment
Abiotic factors	Factors that are physical rather than biological; not derived from living organisms
Biotic factors	Factors relating to or resulting from living organisms
Community	A group of interdependent plants and animals growing or living together in natural conditions or occupying a specified habitat
Population	A community of animals, plants, or humans among whose members interbreeding occurs
Competition	Interaction between animal or plant species, or individual organisms, that are attempting to gain a share of a limited environmental resource
Predation	The preying of one animal on others
Mutualism	Symbiosis that is beneficial to both organisms involved
Parasitism	The practice of living as a parasite on or with another animal or organism
Commensalism	An association between two organisms in which one benefits and the other derives neither benefit nor harm
Adaptation	The process of change by which an organism or species becomes better suited to its environment
Biodiversity	The variety of plant and animal life in the world or in a particular habitat; a high level of which is usually considered to be important and desirable
Sustainability	Avoidance of the depletion of natural resources in order to maintain an ecological balance
Biomass	The total quantity or weight of organisms in a given area or volume
Productivity	The rate of production of new biomass by an individual, population, or community; the fertility or capacity of a given habitat or area
Primary production	The production of raw materials for industry

Student worksheet 1.2 – Ecological interactions

Activity 1: Infographic – abiotic and biotic factors affecting sheep

Abiotic factors include:

- soil - type, moisture, nutrients, chemical properties
- gases in the air
- humidity
- wind speed and direction
- atmospheric temperature

Biotic factors include:

- food availability
- diseases
- pests and parasites
- presence of decomposer organisms
- symbiotic relationships (eg pasture legumes)
- competition from other grazing animals (eg kangaroos)
- predators (eg foxes, cats, dingoes)

Activity 2: Symbiosis – an important biotic factor

Western Australia (WA) primary producers are taking advantage of the symbiotic relationship between legumes such as the lupin and rhizobia bacteria in order to increase efficiency, reduce production costs and to introduce more sustainable pasture management practices.

Growing lupins in the uniquely WA farming system, the wheat: lupin rotation and using inoculum are ways WA primary producers are taking advantage of the symbiotic relationship between legumes such as the lupin and rhizobia bacteria.

Student investigation 2.1

Pre-lab questions

1. Define the following key terms:

Term	Definition
Biotic factor	Factors relating to or resulting from living organisms
Abiotic factor	Factors that are physical rather than biological, not derived from living organisms
Agricultural ecosystem	An ecosystem relating to agriculture
Planting density	The quantity of seeds or seedlings in a given space or area

1. What mathematical units would be most appropriate to describe the planting density of a vegetable crop? Seedlings (plants)/ hectare
2. Calculate the planting density of a tomato crop where a market gardener plants 300 000 evenly spaced tomato seedlings in a 10 hectare field (show your working).

   300 000 seedlings / 10 hectares = 30 000 seedlings/hectare

Student investigation 2.2

Pre-lab questions

1. Define the following key terms:

Term	Definition
Photosynthesis	The process by which green plants and some other organisms use sunlight to synthesise nutrients from carbon dioxide and water. Photosynthesis in plants generally involves the green pigment chlorophyll and generates oxygen as a by-product.
Chloroplast	An organelle in green plant cells that contains chlorophyll and in which photosynthesis takes place.
Cellular respiration	The metabolic process in living organisms by which oxygen is combined with carbon in a cell to form carbon dioxide and generate energy
Abiotic factor	Factors that are physical rather than biological; not derived from living organisms

2. Construct a simple food chain demonstrating how living things (such as humans) are ultimately dependent on the sun for food (and energy).
   Sunlight (not food) → producer organism (green plant) → consumers (animals)

3. When conducting any scientific investigation, what factors need to be considered for it to be considered valid and reliable?
   – factors such as selection and control of variables, consistency of measurement, use of multiple trials/replicates, use of controls (including others) need to be emphasised by students

Student investigation 2.3

Pre-lab questions

1. Define the following key terms:

Term	Definition
Biotic factor	Factors relating to or resulting from living organisms
Symbiosis	Interaction between two different organisms living in close physical association
Agricultural ecosystem	An ecosystem relating to agriculture

2. Describe and provide examples of the major types of symbiotic relationships that occur in nature:

Symbiotic relationship	Description of relationship	Examples of relationship
Mutualism	Symbiosis that is mutually beneficial to both organisms involved	Vascular plants and mycorrhizae Corals with zooxanthellae
Commensalism	Symbiosis between two organisms where one benefits and the other derives neither benefit nor harm	Shark and remora
Parasitism	Symbiotic relationship where one organism lives on or in another organism causing it harm	Numerous examples - malaria, fleas, ticks, or viruses

Student investigation 2.4

Pre-lab questions

1. Define the following key terms:

Term	Definition
Primary industry	Industries associated with production of food or fibre
Adaptation	Process of change by which an organism or species becomes better suited to its environment
Climate change	A change in global or regional climate patterns, in particular, a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric greenhouse gases
Environmental research scientist	A scientist who studies the environment and environmental problems

2. Describe some of the adaptations that Western Australian native plants have for survival in our fire prone environment

Adaptations to fire include:

- Development of woody fruits, where seeds are released after fire
- Thick bark
- Epicormic buds
- Lignotubers

Student worksheet 3.1 – Energy flow in agricultural ecosystems

Activity 1: Energy use in a piggery

Some practices Australian pork producers are doing to:

1. increase the overall efficiency of energy use in their piggeries
- specialise by concentrating on one or more stages of the production cycle
- reducing greenhouse gas emissions
- using renewable energy
2. produce pork ethically and humanely
- ensuring sows are healthy
- antibiotic treatments for sick animals
- working with specialists (eg veterinarians, nutritionists) to have tailored plans to ensure pigs receive the highest standard of care
- legislated minimum welfare requirements for pigs
3. produce pork sustainability
- investing in research and development
- efficient waste management to reduce emissions
- use of renewable energy resources (for example, biogas)

The farrowing shed has the heaviest energy use component across all four of the piggeries. Reasons why this component would have the highest energy use are that the farrowing process requires the maintenance of warm, stable temperatures throughout the farrowing process.

Possible ways that energy use could be made more efficient include use of renewable energy resources.

Activity 2: Piggeries and greenhouse gas emissions

g/AU/day represents grams of GHG per Animal Unit (500 kg of liveweight) per day

Conclusion from data – Deep litter sheds are significantly more effective in reducing GHG emissions than uncovered anaerobic treatment ponds (students need to use some data from the table to justify their answer)

Hypothesis – Microbes that digest the waste are more active in warmer temperatures

Activity 3: Energy use in a chicken farm

Questions:

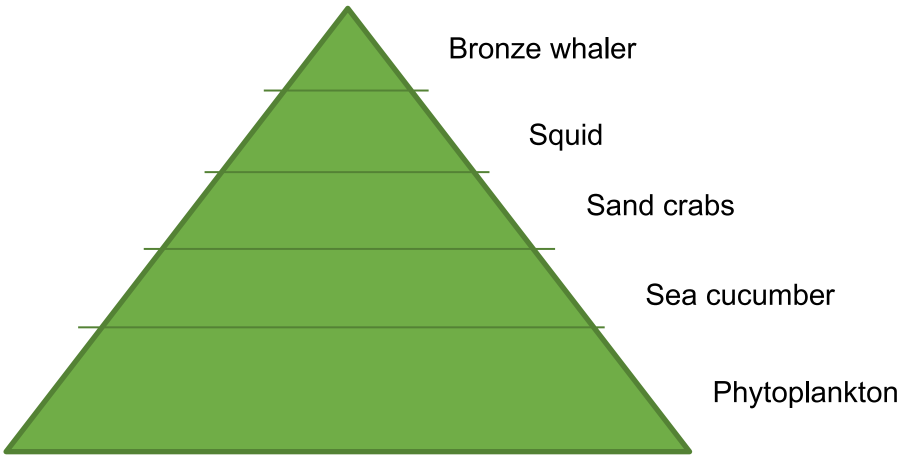
1. It is possible to think of a meat chicken rearing farm as a simple ecosystem. What are the:
- **inputs** to the ecosystem? Day old chickens, food and water
- **outputs** from the ecosystem? Grown meat chickens
2. Describe the **environment** of the meat chicken rearing farm – a large barn with a floor covered with wood shavings or rice hulls
3. Chicken meat farming relies on the changing and control of **biotic** and **abiotic** features of its system. What are the:
- abiotic features that require changing and controlling? Temperature and humidity
- biotic features that require changing and controlling? Pests such as rats and insects, disease causing organisms such as bacteria, viruses and fungi
4. Ultimately chicken produced from an efficient meat farm has the lowest **environmental footprint** of any meat.
- What is an environmental footprint? The effect that a person, company, activity, and so on, has on the environment, for example, the amount of natural resources that they use and the amount of harmful gases that they produce
- How does this low environmental footprint come about? This is the result of the comparatively small space needed by the farm, efficient use of energy in climate control, the efficiency by which chickens convert their food into meat, and when chickens are processed, almost all of the carcass is used for human or animal consumption
5. Describe what you think are the key factors involved in keeping a chicken meat farm **sustainable** and **environmentally friendly**. - managing and controlling the flow of energy and matter, as well as keeping a balance between the biotic and abiotic factors

Student worksheet 3.2 – Marine food webs in WA

Activity 1: WA marine food webs

Questions

1. Producer organisms in the food webs are:
- Cocos Islands – algal beds, seagrass, phytoplankton, coral reefs
- Christmas Island food web – leaf litter and seedlings from the rainforest floor, phytoplankton, coral reefs
- South Coast food web – algae, phytoplankton, seagrass wrack/detritus
2. Food chains will vary between food webs. One example from the South Costa food web is: phytoplankton -> sea cucumber-> sand crabs -> squid-> bronze whaler
3. Producer organisms such as phytoplankton would have the greatest biomass as they need to sustain the other trophic levels
4. The biomass of apex predators needs to be the lowest as they are at the top of the food chain. Considerable energy is lost during energy transfer at lower trophic levels
5. If the numbers of these pilchards or baitfish were reduced by overfishing or disease, then trophic levels below may increase whereas trophic levels above would decrease
6.



Activity 2: Let's examine a species in more detail – pink snapper

How an extensive knowledge of the **biology** of an important species like the pink snapper is essential if the species is to be fished sustainably as well as the ecosystem remaining in balance. Extensive data has been collected on the biology of the pink snapper of the WA coast. This includes knowledge of:

- abundance and distribution
- residence in particular areas and home ranges
- spawning behaviours, seasons and timing
- feeding and residence behaviour
- growth rate and longevity
- dispersal of eggs
- abiotic factors which affect survival of eggs larvae and juveniles

Data has been collected from both commercial and recreational fishers. This data is used to plan fishing sizes, bag limits and fishing seasons in different locations. All of these factors contribute to the sustainable management of the species and the ecosystem.

Student worksheet 3.3 – Aquaculture in WA

Activity 1: What are the main aquaculture species in WA?

Aquaculture species	Why is it grown?	Where in WA is it grown?
Barramundi	Popular table fish with high market value	Kimberley region at Cone Bay
Rainbow trout	Good eating fish that is popular with freshwater anglers	Bred at the Pemberton Freshwater Research Centre then sold to various aquaculture producers and private farm dams
Silver perch	Sold as a live or processed product for human consumption and for aquariums and aquaponics purposes	Mostly grown as part of integrated farming systems in tanks and approved farm dams
Aquarium fish	Attractive, colourful fish such as koi, goldfish, various carps and cichlids, bred for aquariums and aquaponics	Usually grown in tanks and purpose-built ponds by small family-based operators specialising in niche, often high-value, products
Ornamental invertebrates	Corals, live rock and associated products (eg live sand) are grown and sold for display and to maintain healthy water quality of marine aquariums	Different species can be grown in onshore, recirculated or flow through systems and in offshore open water systems
Marron	High value product that is usually sold live	Its culture is almost entirely based on semi-intensive systems using purpose-built earthen ponds
Yabby	Introduced species to WA that is usually sold live	Growing yabbies is restricted to the inland agricultural areas of eastern Wheatbelt and Great Southern regions away from marron production zones
Red claw crayfish	Tropical freshwater crayfish species grown in WA's north that is usually sold live	Almost entirely based on semi-intensive aquaculture using purpose-built ponds
Mussels	Main edible mollusc cultured in WA	Blue mussels are grown near Albany and Cockburn Sound on floating long line and dropline systems
Pearl oysters	Grown for pearls, pearl shell and – on a small scale – for pearl meat	Oysters are grown in hatcheries or collected from the wild
Edible oysters	Important area of aquaculture growth in WA	Oysters are grown in hatcheries and transferred to farms. Grown on line systems, with emerging technologies, such as 'flip' farming systems
Algae	Microalgae grown for beta-carotene production, and for shellfish and prawn aquaculture feed	Reared in large shallow lagoons and ponds north of Geraldton

Student worksheet 4.1: Case study 1: Phytophthora dieback

Activity 1 – Dieback research

Dieback is a symptom of a Phytophthora infection and affects more than 40% of the native plant species and half of the endangered ones in the south-west of WA.

Primary producers (eg foresters, orchardists) are affected severely by loss of production.

Activity 2: Understanding the life cycle of Phytophthora

A life cycle diagram of phytophthora is located at: Phytophthora life cycle

Questions:

1. Phytophthora infects new areas by movement of infected water, soil or plant material; dispersal is favoured by moist or wet conditions
2. The zoospore stage is the most infectious as these have flagella which enable the zoospores to swim in water

Student worksheet 4.2: Case study 2: Queensland fruit fly (Qfly)

Activity 1 – Qfly research

Effects of Qfly on agriculture and the economy: Qfly is considered a serious horticultural pest because it is highly invasive, infesting more than 300 species of cultivated fruits and vegetables. Economic losses are estimated at $300 million, which includes control and loss of production, postharvest treatments, on-going surveillance for area freedom and loss or limit to domestic and international markets.

Activity 2: Understanding the life cycle of Qfly

A life cycle description of Qfly is located at: Agriculture WA – Queensland fruit fly

Questions:

1. Qfly is an Australian fruit fly native to the tropical and subtropical rainforests of Queensland and northern New South Wales. Over time, the clearance of forests for cultivation of fruits and fruiting vegetables and the introduction of exotic fruits has resulted in Qfly increasing its host range and distribution into urban and horticultural areas in Queensland, New South Wales, Victoria and the Northern Territory. The expansion of irrigated agriculture and proliferation of backyard gardens has also allowed Qfly to spread into drier and cooler areas outside its native habitat.
2. The body has three segments and is about 6-8 mm long. The head has two red eyes with two very short antennae (only visible under close inspection). The thorax (middle segment) is reddish-brown with yellow patches on the sides and back. The abdomen (end segment) is a solid dark brown. The legs are a lighter shade of brown and the wings are clear.
3. Excellent information on how to control the spread of Qfly is located at: Qfly information pamphlet - DPIRD

Activity 3: How science and technology are being used to control the spread of Qfly

Advantages of using SIT to control Qfly	Disadvantages of using SIT to control Qfly
Proven to be effective No residual chemical effects Does not harm beneficial insects or the environment	Target areas need to be quarantined Requires intensive human intervention so method may be more expensive

Student worksheet 4.3: Case study 3: Rumen microbes and methane gas emissions

Activity 1: Rumen microbes and methane gas

Infographic illustrating the following: The livestock sector contributes significantly to climate change - 14.5% of all human-caused greenhouse gas (GHG) emissions come from livestock supply chains. They amount to 7.1 gigatonnes (GT) of carbon dioxide equivalent (CO_2-eq) per year. The main sources of emissions are feed production and processing, and methane from ruminants' digestion.

Activity 2: How can we solve the problem? (Cooperative learning jigsaw activity)

Various lines of **scientific research** into solving this problem include:

- vaccinating livestock against certain gut microbes that are responsible for producing methane as the animals digest their food
- biological control methods
- diet supplements and feed alternatives
- selective (genetic) breeding of livestock for lower methane production
- improving pasture management
- improving manure management

Student worksheet 4.4: Case study 4: The dung beetle story

Activity 1: Dung beetle research

Timeline of when, how and why dung beetles were introduced into Australia:

1. The first cattle arrived in Australia with the First Fleet in 1788. Now there are about 28 million cattle around Australia. Every cow makes about 12 cow pads per day, which adds up to around 33 million tonnes of dung across Australia every year
2. Dung beetles were introduced in Australia to help control the number of buffalo and bush flies. The flies breed in unburied cow dung, but dung beetles bury the dung, which stops buffalo and bush flies from breeding
3. The Australian Dung Beetle Project ran from 1964 to 1985. During this time, 55 species of dung beetle were imported into Australia from Hawaii, Africa and southern Europe

Activity 2: Understanding the biology of bushflies and dung beetles

Life cycle and growth

A description of the life cycle of the bushfly can be found at: Propagation of bush fly larvae

Questions

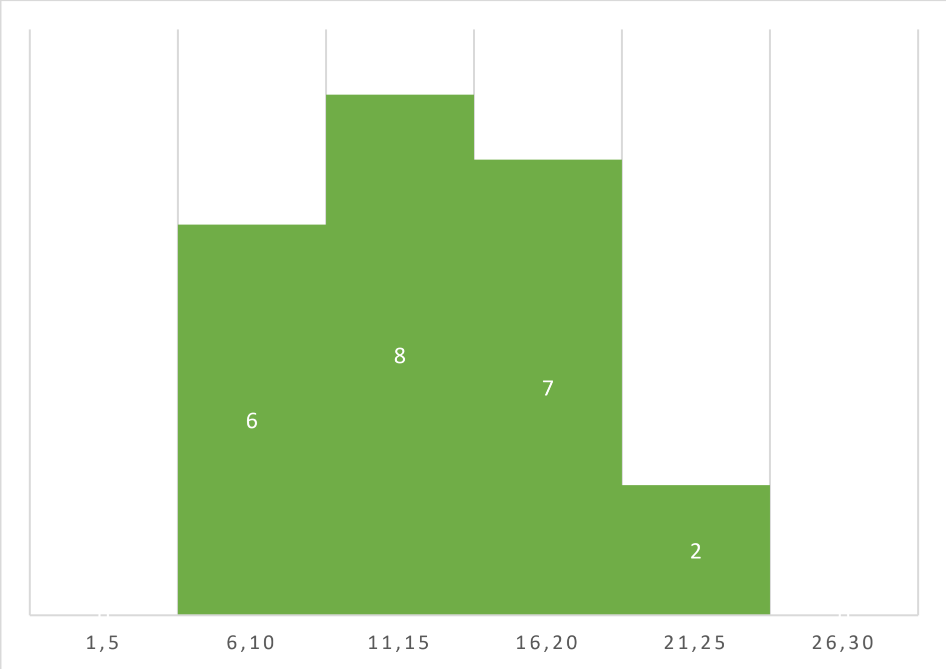
1. The bush fly obtains its food by sucking up bodily fluids such as sweat, saliva and tears.
2. Adaptations the bushfly has that enable it to avoid being swatted include having two sets of wings; one large and a much smaller set of hind wings called halteres, which are sophisticated organs that enable the fly to balance and turn suddenly. These halteres give them the specific ability to evade being swatted.

Dung beetle biology

Classification	Class Insecta, Order Coleoptera, Family Scarabaeidae
Identification	Dung beetles have three body parts - a head, a prothorax and an abdomen. The body consists of a hard outside cuticle and folded wings that lie over the upper surface of the abdomen and are covered by wing covers. The wings are transparent or whitish in colour and are only visible if the beetle is in flight. Dung beetles have six legs that are specialised for shovelling dung and earth. Dung beetles come in a variety of colours. The most common colour of dung beetles in Australia is black
Distribution	Australia has more than 500 species of native dung beetles and 29 species of dung beetles were successfully introduced from Hawaii, Africa and southern Europe. The introduced dung beetles are very useful in Australia's agricultural regions
Seasonality	Most dung beetle species reproduce in the warmer months of spring, summer and autumn
Life history cycle	A pair of dung beetles (a male and a female) may work together, digging a nest to create a burrow beneath the dung pad. The dung is taken into the burrow in either a ball or an irregular mass. The female lays her eggs in the burrow. The eggs hatch into larvae, which feed on the dung surrounding it. The larvae will go through three skin changes to reach the non-feeding pupal stage. Male larvae develop into major or minor males depending on how much dung is available to them during their larval phases. Some dung beetle larvae are able to survive unfavourable conditions, such as droughts, by stopping development and remaining inactive for several months. The pupae turn into adult dung beetles, which break out of the dung ball and dig their way to the surface. The newly formed adults will fly to a new dung pad and the whole process starts over
Ecological impacts	Dung beetles serve a number of very important ecological functions. The digging activity of tunnelling beetles results in the aeration of soil as well as the transfer of nutrients to the soil by releasing the nutrients in the dung. Also, dung beetles break down dung and prevent flies from breeding in it

Activity 5: Collating and analysing data on dung beetles

1 Histogram of numbers of species of dung beetles in different length ranges



2. Ten species are present in WA
3. Eight species are active in summer, two are active in winter
4. Dung beetle numbers may decline leading to an increase in bush fly numbers as no other of species of dung beetle is as wide-spread or active in the winter.
5. WA's agricultural regions are spread over a diverse range of climate and soil types. In order to cover all of these during both summer and winter, a large number of different species is needed.

Cattle dung and greenhouse gas emissions

Activity 5: Analysing an experiment on dung beetles

Questions

1. A different number of dung beetles of each species was used in the various treatments because each species varied in size and mass
2. One species of dung beetle is much more effective at removing dung from the experimental environment.
   a) T4 is the most effective
   b) T4 is the largest and is a large tunneler species
3. Examine figure 3. State two conclusions about dung beetles and greenhouse gas emissions that can be drawn from the data:
   Conclusion 1: Different dung beetle species contribute differently to dung removal

   Conclusion 2: Different dung beetle species contribute differently to reduction of GHG emissions from cow pats

Acknowledgements

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