
REFRACTION
MEDIA
mla
MEAT & LIVESTOCK AUSTRALIA
Biodiversity
protecting the environment
Study guide

ENVIRONMENTAL CUSTODIANS

Farming livestock is a complex undertaking, with many factors, such as climate, animal health and market forces, influencing day-to-day and year-to-year activities. But the most important factor is the health of the farming environment, and especially the maintenance of a vibrant and healthy ecosystem of pasture, tree and plants, wildlife and livestock. In a word, biodiversity.

Australian cattle and sheep farmers are leading the way in developing successful methods and practices to preserve and enhance biodiversity across their farms. This has major benefits not only for the farm and the farmer, but also for the wider environment. In this special study guide, we look at the many challenges and opportunities that cattle and sheep farmers are embracing in their daily operations as they work to improve the health of the land, an endeavour that is building a better environment for us all.

MEAT & LIVESTOCK AUSTRALIA FOR A SUSTAINABLE FUTURE

Meat & Livestock Australia is an initiative by Australian cattle and sheep farmers, along with the broader industry, to deliver sustainable farming by 2020. It's a commitment to take positive action, both big and small, to continually improve the way farmers operate, and to improve sustainability throughout the red meat supply chain.

Sustainability isn't a new thing – the whole Australian cattle and sheep industry has been investing in environmental research and development for many years. It continues to invest more than $13 million every year in research and development to reduce the industry's environmental impact through improved farming practices.

As caretakers of the land, farmers are committed to leaving it in better shape than when they found it by improving efficiency and reducing resources used. Apart from harnessing the latest technology and science to reduce farming's footprint, Meat & Livestock Australia is also about sharing ideas, celebrating successes and providing a focal point for environmental, social and ethical farming action to ensure we all enjoy a sustainable food supply into the future.

Content by Jane Lewis and Sally Parker
Editor Jonathan Nally
Art director Tim Verrender
Designer Lucy Glover
Sub-editor Rivqa Rafael
Managing Editor Heather Catchpole
Editor-in-chief Wilson da Silva
Publisher Kylie Ahern
Published in conjunction with Meat & Livestock Australia: goodmeat.com.au/education

HOW TO USE THE GUIDE

The notes in this study guide offer both variety and flexibility of use for the differentiated classroom. You and your students can choose to use all or any of the five sections – although it is recommended to use them in sequence, along with all or a few of the activities within each section.

THE 'FIVE Es' MODEL

This guide employs the 'Five Es' instructional model designed by Biological Sciences Curriculum Study, an educational research group in Colorado. It has been found to be extremely effective in engaging students in learning science and technology. It follows a constructivist or inquiry-based approach to learning, in which students build new ideas on top of the information they have acquired through previous experience. Its components are:

Engage Students are asked to make connections between past and present learning experiences and become fully engaged in the topic to be learned.

Explore Students actively explore the concept or topic being taught. It is an informal process where the students should have fun manipulating ideas or equipment and discovering things about the topic.

Explain This is a more formal phase where the theory behind the concept is taught. Terms are defined and explanations given to models and theories.

Elaborate Students develop a deeper understanding of sections of the topic.

Evaluate Teacher and students evaluate what they have learned in each section.

Improving biodiversity

Australia's cattle and sheep farmers are the custodians of 47% of the nation's land, and take their environmental responsibilities seriously.

As caretakers of nearly half the continent, Australian cattle and sheep farmers aim to continually improve their practices to produce food sustainably in a changing environment. Australian cattle and sheep farmers are developing ways to minimise their environmental footprint, and improve the health and vitality of farmlands and the plants and wildlife they support. They're doing this by:

- Managing soils and groundcover to produce environmental and commercial benefits. By understanding the interactions between the soil (part of the lithosphere), the biosphere (living things) and hydrosphere (water), and how matter cycles between these spheres, farmers are actively taking steps to sustainably manage the land.
- Controlling native and introduced plant and animal pests. By doing this, cattle and sheep farmers are having a positive effect on the food chains that exist on their properties – organisms that best maintain the ecosystem are being encouraged; and organisms such as weeds or feral animals, which often destroy the biotic (living) and abiotic (non-living) balance are being discouraged.
- Protecting, managing and enhancing existing biodiversity, which has a positive impact on the environment by restoring areas affected by past farming practices.

SOIL AND GROUNDCOVER

Healthy soils create environmental benefits through the efficient and sustainable use of water and nutrients, leading to higher productivity for pastures (land used for grazing). Healthy soils also prevent water run-off, erosion and reduce deep drainage.

Deep drainage occurs when water leaks below the root zone of plants and into groundwater and springs, and represents a loss of water that might otherwise have been available for crop or pasture production. While deep drainage is a natural process that leads to the recharge of the groundwater and springs that flow into creeks and rivers, excessive deep drainage can lead to dryland salinity problems (salinity in agricultural soil that isn't irrigated).

Well-managed soils can also store large volumes of atmospheric carbon dioxide, which can improve soil water capacity, nutrient retention and pasture productivity as well as help moderate Australia's overall carbon-dioxide emissions.

Groundcover management is very important. Groundcover refers to grasses and shrubs that help hold the soil together and protect from it erosion. A comprehensive independent survey of the environmental practices of Australian cattle and sheep farmers in 2010 found that 81% of Australian cattle and sheep farmers actively manage the groundcover on their properties, reducing the environmental impact of their grazing practices.

THREATS TO SOIL HEALTH

Australia's cattle and sheep farmers know that without effective soil and groundcover management, the long-term sustainability of their livelihood is at risk. The main threats to soil health include:

- Soil loss – intense rainfall, sloping topography and unstable surface soils can create a high risk

of soil loss through water erosion on many land types. Wind erosion can also occur with lighter soils. Maintaining adequate groundcover, such as grass and shrubs, can protect and hold the soil together and reduce these losses.

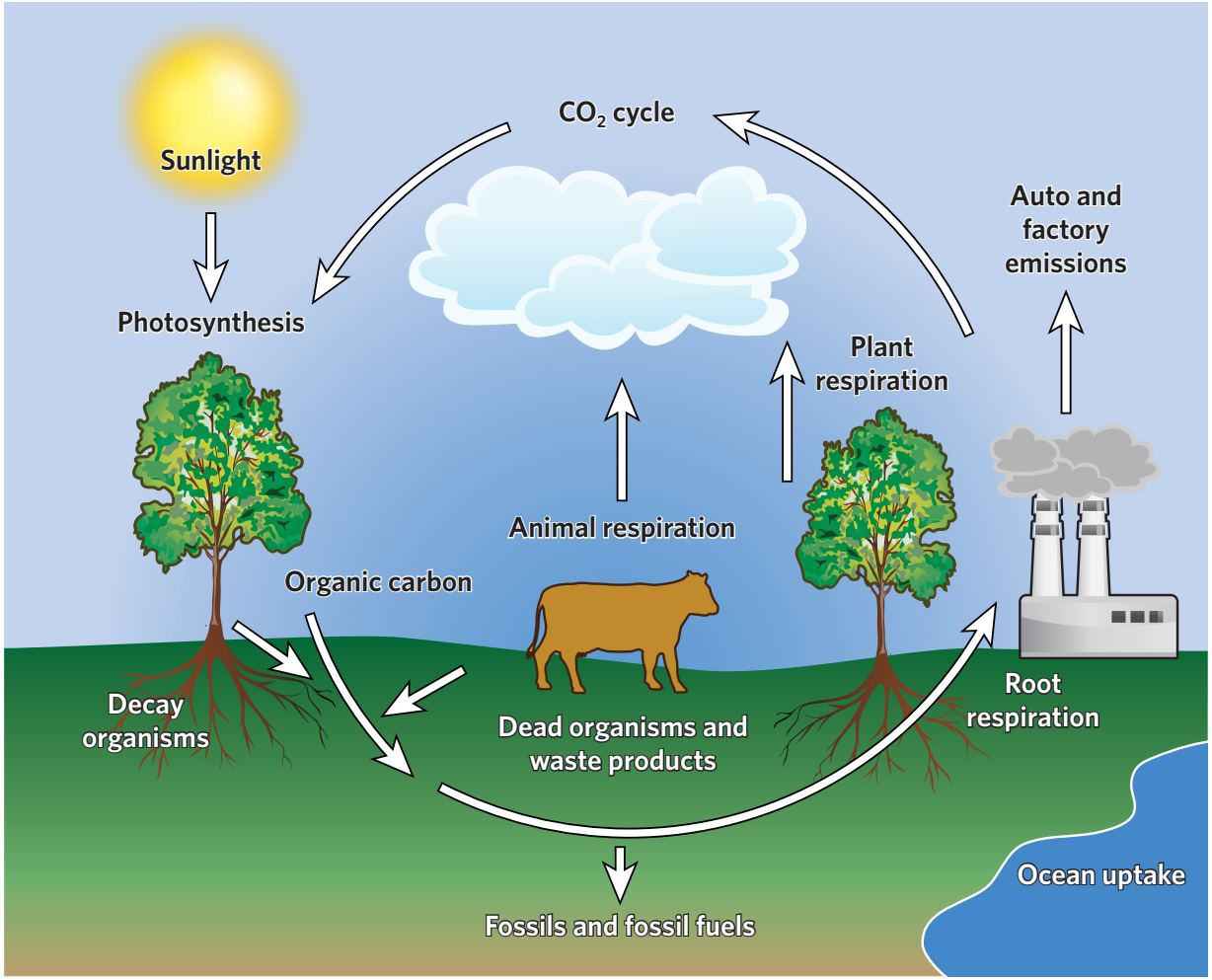
■ Soil fertility – poor grazing practices can result in a decline in soil fertility (ie, nutrient levels), on many types of land.

■ Dryland salinity – many soils in Australia already have inherently high salt levels below the surface layer, known as the subsoil. This can be exacerbated when the replacement of native vegetation with pastures increases the potential for harmful deep drainage (see above), which can raise the underground water level and bring brackish water (water that is somewhat saltier than fresh water) close to the surface, resulting in an increased risk of development of dryland salinity. Good management can reduce deep drainage and thereby minimise the potential chances of farmland dryland salinity occurring.

■ Surface water quality – soil particles (as well as pesticides and salts) in run-off water can reduce the quality of surface water.

■ Soil compaction – poor pasture management and overgrazing can cause the soil to compact, reducing its capacity to retain carbon and absorb water.

■ Soil carbon – soil can be both a source and an absorber of greenhouse gases. While greenhouse gas emissions can occur after tree clearing; some land management practices, such as pasture improvement – by, for example, using fertilisers and irrigation – can increase soil carbon content.



The carbon cycle depicts how carbon moves throughout the environment, both naturally and artificially.

PROTECTING SOIL AND GROUNDCOVER

A range of research and development projects are undertaken by the cattle and sheep industry to improve soil and groundcover.

BETTER DUNG BEETLES

Dung beetles bury and consume cattle and sheep dung. In the process, they put nutrients into the soil, which helps new pasture grow. But during the two- to three-month gap of winter and early spring, dung beetle activity across southern Australia decreases, resulting in nutrients not being recycled into the soil. This is an important missed opportunity to minimise dung pollution and enhance pasture growth in the spring. To tackle this problem, a project by CSIRO Ecosystems Sciences is underway to import two species of dung beetles from France and Spain that are active at different times of the year, in preparation for release at five test sites in September 2014.

RESTING THE LAND

'Resting' pastureland means keeping stock off it to let it recover after grazing. During the wet season, resting is a key aim for improving grazing pastures in the northern half of Australia. Resting can improve soil quality and groundcover, and reduce the risk of erosion and downstream impacts on water quality. Not enough is known about the best ways to rest pastureland in northern Australia, so farmers and researchers are working together to study the effects of different resting systems, with the goal of improving groundcover and productivity on their farms.

IMPROVING RUNDOWN PASTURES

The gradual loss of soil and the decline of soil quality in pastures sown solely with grass reduces production by approximately 50% over five to 20 years, and is expected to cost beef producers in northern Australia more than $17 billion at the farm gate over the next 30 years.

But research conducted by the Queensland Department of Agriculture, Fisheries and Forestry has shown that incorporating legumes into otherwise grass-only pastures (primarily in southern and central Queensland) dramatically boosts pasture production, animal performance and economic returns, with the benefits far exceeding other methods, such as the use of herbicides and fertilisers.

123RF

123RF

PESTS AND WEEDS

Australian cattle and sheep farmers devote significant time and money to managing pests and weeds on their land. Their efforts provide benefits far beyond the farm gate by reducing the spread of weeds to sensitive natural areas and protecting native species.

WEEDS

Weeds are estimated to cost Australian farmers about $4 billion each year in weed-control activities and lost agricultural production. Weeds reduce farm productivity by invading crops, smothering pastures and in some instances harming livestock. They aggressively compete for water, nutrients and sunlight, resulting in reduced crop yield and poor crop and pasture quality.

PESTS

Pest animals damage crops, prey on livestock and native wildlife and compete for pasture. More than 50 animal species have been introduced into Australia since the late 1800s and are now considered to be invasive animals.

MEAT & LIVESTOCK AUSTRALIA

Rabbits, feral pigs, foxes and wild dogs are of greatest concern to cattle and sheep farmers.

Pest animals can potentially spread serious diseases, cause land degradation by spreading weeds and contribute to soil erosion and poor water quality.

A comprehensive independent survey of the environmental practices of Australian cattle and sheep farmers in 2010 found that 88% of farmers actively control pest animals.

CONTROLLING PESTS AND WEEDS

A range of research and development projects to combat pests and weeds are funded by Australian cattle and sheep farmers. These include:

Unmanned aircraft control of weeds

Unmanned aerial vehicles are being trialled as a way to monitor and control weeds on large cattle stations in northern Australia. To date, the aircraft and associated sensing software have been used to test ways to detect and map weeds, and ongoing work is looking to improve the reliability of weed detection.

Prickly acacia control

Classed as a weed of national significance by Australian governments, prickly acacia affects grazing in northern Australia. A potential bio-control agent for prickly acacia has been found in India, and laboratory tests are underway to test its suitability for controlling the weed in Australia while confirming it will not attack non-target species. If successful, the suppression of prickly acacia will reduce mustering costs, avoid ongoing weed control costs, and increase pasture production.

MEAT & LIVESTOCK AUSTRALIA

Humane control of feral pigs

A newly developed sodium-nitrite feral-pig bait, called HOG-GONE, is to be registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA). This bait is a more humane control agent for feral pigs and offers the further advantage of an antidote in the event of accidental poisoning.

Parkinsonia dieback workshops

Parkinsonia (*Parkinsonia aculeata*; below right) is classified as a weed of national significance that threatens rangelands and wetlands. Research undertaken has identified a range of naturally occurring soil fungi that have adapted to use parkinsonia as a food source and therefore control it. A project is now underway to hold workshops across Parkinsonia-affected areas in Queensland to train landholders, land managers and researchers in the use of the fungal control agents.

MEAT & LIVESTOCK AUSTRALIA

BIODIVERSITY

Past agricultural practices, where the land was farmed in a European fashion and native vegetation was removed to make way for pasture and crops, led to a decline in biodiversity. The philosophy of working with the land, not against it, is now widely practised. Here are some of the ways in which cattle and sheep farmers are improving biodiversity on the land.

NATIVE RESOURCE MANAGEMENT

Careful monitoring and management of natural resources results in improved productivity and farm sustainability. Cattle and sheep farmers protect, manage and enhance biodiversity on grazing farms by:

- Retaining
- Restoring
- Revegetating

Planting trees and shrubs can alleviate problems such as erosion and soil structure decline, making the land more productive as well as increasing biodiversity.

Many cattle and sheep farmers are dedicating areas of their property to revegetation, fencing remnant and revegetated areas to exclude stock and feral animals and pests, and planting tree belts to protect stock and to provide shelter for native fauna.

LANDCARE

Many Australian cattle and sheep farmers are active members of Landcare groups and have been since the project's inception in 1989. Landcare was established by the National Farmers' Federation and the Australian Conservation Foundation to provide a vision for the transformation to ecological sustainability through collective community-led groups.

ENHANCING BIODIVERSITY

Targeted research is protecting and enhancing biodiversity on cattle and sheep farms across Australia. Examples of this research include:

- **Sustainability guide**

A special sustainability guide has been made available to all Australian farmers. Called Towards Sustainable Grazing, it is a comprehensive collection of information on best-practice, modern grazing enterprises in southern Australia, underpinned by six years of research and development and the experiences of thousands of farmers. *mla.com.au/news-and-resources*

- **Northern weedy perennial legume monitoring**

A five-year monitoring and eradication program is currently underway in northern Australian grazing lands, targeting four weedy legumes that grow year round. Expected outcomes from the project are: reduced invasive weeds, improved cattle and sheep production, and improved biodiversity on farms.

SUMMARY

Cattle and sheep farmers recognise that healthy, diverse and productive ecosystems are vital to the viability of their livelihoods and their ability to continue providing high-quality beef and lamb to Australian and international consumers. The multitude of positive steps cattle and sheep farmers are undertaking to reduce environmental impacts and boost biodiversity on their farms ensures the sustainability of this vitally important industry.

UNIVERSITY OF SYDNEY

Name: Salah Sukkarieh

Location: University of Sydney

Web: *sydney.edu.au/engineering/people/salah.sukkarieh.php*

Green machines

Robotic aircraft once confined to military use have the potential to fight weed infestations more efficiently, and with less environmental impact.

Robotics engineer Salah Sukkarieh is working on modifying military pilotless aircraft for use in agriculture.

IT WAS LESS than 10 years ago that robotics engineer at the University of Sydney, Salah Sukkarieh, says he first noticed the cost of robotic aircraft technology plummeting. With cheaper autopilots, platforms, cameras and sensors entering the mainstream market, unmanned aerial vehicles (UAVs), best known for their use as military drones, no longer had to be confined to big-budget aerospace companies.

So in 2006, with his colleagues at the Australian Centre for Field Robotics, Sukkarieh began working with Meat & Livestock Australia to use the small pilotless planes for civilian purposes: namely, to identify and locate woody weeds on expansive cattle properties. Woody weeds, such as prickly acacia, mesquite and parkinsonia, are a persistent headache for Australian farmers, reducing biodiversity by competing with other, useful grasses, and adding difficulties and costs to mustering. However, current approaches to dealing with infestations are often inconsistent and based on incomplete information, Sukkarieh says.

"Generally, what happens is the farmer just decides they should get rid of these weeds before they spread even further," he says. "There's no real estimate of how many weeds there really are on the farm."

That's where the drones come in – flying as low as 150m over large stretches of land, they can use sophisticated machine-learning algorithms to accurately identify, categorise and locate weeds with to-the-centimetre precision. The collected data can then be communicated to another UAV, which dispenses granular herbicide to exactly where it's needed – reducing collateral environmental damage, while saving money and fuel by taking the most efficient routes between weed sites. The lack of a pilot also adds to fuel savings, while increasing safety by removing humans from a potentially dangerous occupation.

> "Robotics [can] increase the knowledge and information you have about your farm."

While the UAV technology is straight off the shelf, the algorithms used to identify and classify the weeds were research-orientated, says Sukkarieh, who is currently investigating different UAV platforms with features such as automatic takeoff and landing, so that trained farmers or consultants can operate the system.

Sukkarieh, whose enthusiasm for Formula 1 car racing originally inspired his undergraduate degree in mechatronics, has high hopes for the future relationship between robotics and next-generation, sustainable agriculture.

As well as previously working with Land and Water Australia identifying aquatic weeds, Sukkarieh says he recently started another project using ground robots in crop harvesting, identifying ripe fruits and estimating yield. And there could even be potential for automated livestock herding, he adds.

"Robotics offers the potential to increase the knowledge and information you have about your farm," Sukkarieh says. "You have greater control over the system, and a lot greater predictability." – *Gemma Black*

Life on the land

Imagine you are a farmer who owns a large property, on which cattle and sheep graze. As well as your stock animals, there are many other species that call the property home. Can you think of any other types of animals that would live on your land? What about organisms other than animals?

1. Read the list of organisms below, then categorise them by writing them in the correct position on the Y chart. Tick them off as you enter them on the Y chart.

Species to categorise
Cows, kangaroos, sheep, ticks, wild rabbits, feral deer, feral pigs, blackberry, lippia (weed), bandicoots, eucalypts, grass, bees, kookaburras, magpies, butterflies, fleas, soil microbes, intestinal worms, Paterson's curse, earthworms, dung beetles, spiders

2. What are the benefits of having the welcome species on the property?

_____

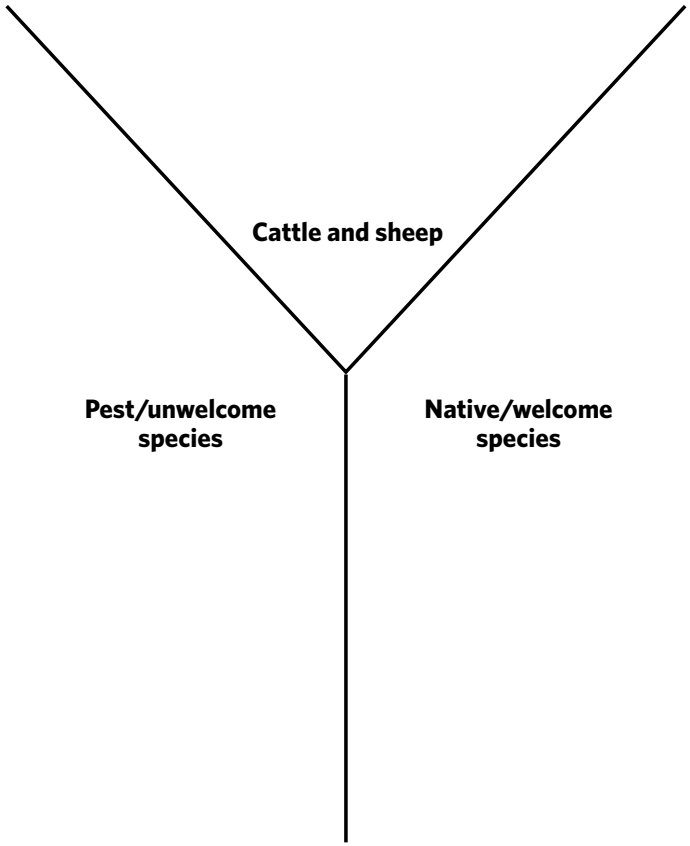
_____

_____

_____

_____

_____



Lippia is classified as a noxious weed in New South Wales, and causes problems in Queensland.

MEAT & LIVESTOCK AUSTRALIA

A southern brown bandicoot.

MGOREY/WIKIMEDIA

3. What are the drawbacks of having the unwelcome species on the property?

Now that you have thought about the different kinds of organisms that might live on your property, and whether they benefit or hinder your business, think about how you could manage your land to enhance the biodiversity of the welcome species. How can you get the most out of your cattle and sheep while at the same time protect native species and control pest species?

Managing biodiversity can be a challenge! Consider the following questions to help brainstorm some biodiversity-enhancing ideas when managing crops.

Questions for discussion:

1. Why is maintaining biodiversity on farms important?

2. What kinds of things might you be able to do to keep the pest animal species under control while protecting native species and your cattle and sheep?

3. How might you be able to control weeds while protecting your pastures?

4. How might planting native trees help maintain or improve biodiversity on a farm?

5. What are some other things you could do to manage or improve the biodiversity on your farm?

A purple field of Paterson's curse.

AUSSIEGAL/WIKIMEDIA

A kookaburra.

BRISBANE CITY COUNCIL/WIKIMEDIA

Teacher's information

The aim of the Explore section is for students to investigate some of the ideas around biodiversity and managing farmland. It is intended that students make their own discoveries as they work around the stations in the room.

The equipment table below lists the equipment and preparation required.

Station no.	Station activity	Materials list
1	Land and soil management comparison using the videos on the Virtual Farm Visit	Computer to access the website: *virtualfarm.mla.com.au*
2	Protecting animals and plants comparison using the videos on the Virtual Farm Visit	Computer to access the website: *virtualfarm.mla.com.au*
3	Testing soil pH	Universal indicator and colour chart, several soil samples, test tubes, beakers, pipettes
4	Biodiversity numbers	Statistics provided
5	Increasing biodiversity	Aerial photo of a farm (provided)
6	Farm food chains and webs	Photos of organisms living on a farm (provided)

Station 1

[Task] Land management

1. Go to *virtualfarm.mla.com.au*

2. Watch the following three videos on land management. Each video is about one of the three farms as indicated in the table below.

Criteria for comparison	Iona	Malabar Farm	Kalyeeda Station
Location of farm	Yeoval, NSW	Gippsland, Victoria	The Kimberley, WA
Farmer	Andrew	Paul	James
Location of video on Virtual Farm	Click on the grass, then on 'Technology' and then on 'Crop and Pasture Management'.	Click on the grass, then on 'Society and the Environment' and then on 'Land Management'.	Click on the green grass, then on 'Society and the Environment' and then on 'Pasture Management'.
Outline how the farmer manages the land and crops			

3. Identify any **similarities** between the way the three farmers manage their land and crops.

4. Identify any **differences** between the way the three farmers manage their land and crops.

Station 2

[Task] Protecting animals and plants

1. Go to *virtualfarm.mla.com.au*

2. Watch the following three videos on the use of pesticides and herbicides. Each video is about one of the three farms as indicated in the table below.

Criteria for comparison	**Iona**	**Malabar Farm**	**Kalyeeda Station**
Location of farm	Yeoval, NSW	Gippsland, Victoria	The Kimberley, WA
Farmer	Andrew	Paul	James
Location of video on Virtual Farm	Click on the cattle, then on 'Science' and then on 'Animal Health'.	Click on the lamb, then on 'Science' and then on 'Protecting Animals'.	Click on the cattle, then on 'Science' and then on 'Managing Insects and Pests'.
Do they use herbicides? If so, against which plants?			
How do they apply the herbicide?			
Do they use pesticides? If so, against which animals?			
How do they apply the pesticide?			

Station 3

[Task] pH of soil samples

Farmers need to maintain optimal soil quality, so their pastures and crops grow well. One of the tests they can do to check their soil is a pH test.

1. Observe the colour and texture of each soil type. Is it sandy, clay like, dark or light brown?
2. Mix one spatula of one of the soil types in a clean beaker with 10mL of water.
3. Let the sediment settle, then remove a little of the soil water and place it in a test tube.
4. Use the universal indicator and colour chart to test the pH of the soil water.
5. Repeat for the other soil samples and design a data table in the space provided below to record your results:

6. Was there much difference between the pH of the soil types? Write a sentence or two to communicate your findings.

7. Which soil do you think might be best to grow crops in? Justify your response.

Station 4

[Task] How many?

When sheep or cattle farmers manage biodiversity on their farms, they not only have to consider the number of different organisms on their property, but also the population size of each of those organisms.

1. Next to each organism in the table, write in the most likely population size of each, choosing from the following; 2, 240, 25, 10,000,000.

Organism	Most likely population size	Justification for your choice	What a farmer might have to do to manage this organism
Sheep			
Eucalypt			
Soil microbes			
Wild dogs			

ISTOCK

Station 5

[Task] Increasing biodiversity on a farm

Annotate or draw on this photo of a farm to show any changes that could be made to improve the farm's biodiversity. Suggest how these changes you have made could increase the number of different organisms that live on this farm.

Station 6

[Task] Farm food webs and chains

1. Look at the photos of the various organisms that might live on a cattle and sheep farm.

2. Design a food chain that could exist on a farm using some of the organisms shown here (bird, grass, flower, calf, eucalyptus tree, feral pig, blackberry bush, bee, butterfly, lamb).

3. Would the food chain you have drawn be one that is likely to be encouraged by the farmer? Why or why not?

_____


BRISBANE CITY COUNCIL


ALEX PROIMOS


ROGER KIDD


PAUL MORRIS


VICKI NUNN


JOHN O'NEILL


FIR0002/WIKIMEDIA


PERIPITUS/WIKIMEDIA


FIR0002/WIKIMEDIA


ISTOCK

Health of the land

Student literacy activities

In this section, we delve into the issues associated with biodiversity and the cattle and sheep industries, and explain some of the science involved. Students read a series of articles and complete several linked discussion topics and literacy activities. These include:

- Brainstorm.
- Glossary.
- Comprehension and summary.
- Questioning toolkit.

Before reading the articles, students share what they already know about biodiversity by taking a quick quiz.

ARTICLES

1. Biodiversity and farming
The cattle and sheep industry is adopting a range of strategies to protect and manage the biodiversity of Australia's farmlands.

2. Farmers by another name: environmental stewards
Farmers are best known for growing crops and raising livestock, but there's another very important role they play as land managers.

3. Farm case studies
Many farms around the country are being run in a way that doesn't simply make money, but also conserves the native plants and cattle and sheep that call these places home, as these case studies show.

Brainstorm

[Task] How much do you know about biodiversity? Take this quick quiz to find out.

1. How many species of plants and animals are estimated to live on Earth? _____
2. About how many new species are discovered by scientists each year? _____
3. How long will it take to find all unknown species? _____
4. What percentage of species is thought to remain undiscovered? _____
5. How many species are thought to live in Australia? _____
6. True or false: Australia is one of the most biodiverse countries in the world. _____
7. True or false: Australia has lost more biodiversity than any other continent over the past 200 years. _____
8. How many species of animals in Australia are classified as 'threatened'? _____
9. What proportion of animal species in Australia are 'invasive' (non-native)? _____
10. How many invasive species of plants are there in Australia? _____

(answers on next page)

Brainstorm answers

1. Between 8 and 11 million (not including prokaryotes such as bacteria)
2. About a thousand
3. About 500 years
4. More than 80%
5. 570,000
6. True
7. True
8. More than 400
9. About 6%
10. More than 2500

Biodiversity and farming

BIODIVERSITY IS THE VARIETY of all lifeforms on Earth – all the different plants, animals and microorganisms, and the ecosystems they live in.

In the context of sheep and cattle farming, biodiversity refers to the woodlands, native scrub, trees, shrubs and native grasses, as well as the insects and other animals that live on farms. Cattle and sheep farmers strive to manage the environment in a way that not only allows this rich biodiversity to coexist with their stock, but also helps biodiversity thrive.

Changing farming practices

All forms of food production contribute to a loss of biodiversity to varying degrees, and it is important that impacts on biodiversity are managed effectively. There is no denying that farming practices throughout the 1800s and first half of the 1900s had some detrimental impacts on Australia's biodiversity. This was mainly due to government-mandated land clearing, in a belief that Australia should be farmed using European methods. Land clearing reduced areas of native vegetation that, coupled with some traditional land management practices, resulted in a decline in biodiversity.

Today, cattle and sheep farmers strive to protect, manage and enhance biodiversity on their land. For example, planting native trees and shrubs on grazing properties can help alleviate problems such as erosion and soil structure decline, making the land more productive as well as increasing biodiversity and providing natural shelter.

Natural resource management

Biodiversity is a priority natural resource management (NRM) issue for the cattle and sheep industries. Cattle and sheep farmers nationwide have responded to the challenge of biodiversity conservation by:

- dedicating areas of their farms to revegetation;
- fencing remnant vegetation and revegetated areas to exclude stock and feral animals;
- planting tree belts to protect stock and to provide shelter for native fauna.

NRM is an important activity on 94% of Australian farms, resulting in improved productivity and sustainability. By applying three principles – retain, restore and revegetate – cattle and sheep farmers can protect and even enhance biodiversity on their farms.

Australian cattle and sheep farmers are planting more trees for environmental purposes than a decade ago. In 2001, farmers planted 20.6 million tree seedlings for NRM, compared with nine million in 1991. On average, each Australian farmer plants 150 tree seedlings a year, solely for conservation purposes.

Landcare

Many of Australia's cattle and sheep farmers are active members of Landcare groups, and have been since Landcare's inception in 1989. Landcare was established by the National Farmers' Federation and the Australian Conservation Foundation to provide a vision for transformation to ecological sustainability through collective community led groups (see Article 2).

Managing fire

Protecting and maintaining remnant vegetation involves managing woody cover in native pasture areas. Woodland thickening affects large parts of Australia, reducing the capacity of farms to carry stock by limiting native pasture growth and ground cover. In conjunction with other stakeholders, the sheep and cattle industry is developing a series of recommendations for how fire can be used to manage vegetation and create a better balance between woody vegetation and native pastures.

Research and development

The cattle and sheep industry invests significantly in research and development, to better understand biodiversity on farms and how it can be optimally managed. For example, research undertaken by EverGraze (a Meat & Livestock Australia, Future Farm Industries Cooperative Research Centre and Australian Wool Innovation research and delivery partnership) is testing the hypothesis that high-intensity grazing of native pastures improves productivity at the same time as increasing biodiversity.

The balance between trees and grass is a recognised factor influencing productivity, environmental stability and biodiversity. In northern Australia, a research project is underway to measure the beneficial effects of trees. This work will contribute to new management guidelines to improve decision-making about grazing and land management, land clearing or tree retention, salinity and carbon sequestration.

Research into burning strategies on grazing properties is also underway. The aim of this research is to help farmers find the right balance between ensuring there is enough forage for productive grazing, while maintaining sufficient fuel for fires to control woody weeds.

See goodmeat.com.au/education for more information about industry initiatives to deliver sustainable cattle and sheep farming by 2020.

Activity 1 – Glossary

[Task] Define some of the scientific terms used in Article One, using the table provided.

Term	Definition
Biodiversity	
Native scrub	
Farming practices	
Government-mandated land clearing	
Traditional land-management practices	
Grazing properties	
Soil structure	
Natural resource management	
Remnant vegetation	

Term	Definition
Revegetation	
Stock	
Tree belts	
Productivity	
Ecological sustainability	
Carbon sequestration	
Woodland thickening	
Ground cover	

Activity 2 – Summarise

[Task] Answer the following questions relating to Article One.

1. List some of the biodiversity that exists on sheep and cattle farms, mentioned in the article.

2. The article includes the comment that "all forms of food production contribute to a loss of biodiversity".

a) What do you think this comment means?

b) Do you agree with this comment? Why or why not?

c) Can you think of another type of food production (other than beef and lamb production) that contributes to a loss of biodiversity? Explain your answer.

3. Fill out the table to show some of the actions the livestock industry is taking to protect and manage biodiversity on farmland, and suggest what this action is aimed at.

Actions	**Aims**
Example: Revegetation	Example: To replace native trees and provide habitat for native animals

4. The article mentions that the sheep and cattle industry invests in biodiversity research.

a) Why does the industry make this investment?

b) Give one example of research being done, and what it is aimed at achieving.

Activity 3 – Questioning Toolkit

[Task] Write your ideas and opinions relating to each of the different types of questions.

Inspired by Jamie McKenzie's Questioning Toolkit. Further reading on questioning toolkits: McKenzie, Jamie (2000) Beyond Technology, FNO Press, Bellingham, Washington, USA. *fno.org/nov97/toolkit.html*

Type of question	Your ideas and opinions
Essential questions These are the most important and central questions. They probe the deepest issues that confront us and can be difficult to answer. **Questions** What is biodiversity? Why is biodiversity important? Should we conserve biodiversity? What can we do to conserve biodiversity?	
Subsidiary questions These questions help us to manage our information by finding the most relevant details. **Questions** How can we best manage the biodiversity living on land used for food production? Will biodiversity stay at the same level, decline, or increase over the years? What are the main factors that are contributing to loss of biodiversity?	

Type of question	Your ideas and opinions
Hypothetical questions Questions designed to explore the possibilities, the 'what ifs?' They are useful when we want to test our hunches. **Questions** What will happen if people do nothing to protect biodiversity, and only look after economically important species like those we use for food? What would Australia's native biodiversity be like now if we hadn't introduced so many non-native species?	
Provocative questions Questions to challenge convention. **Questions** Do we take the biodiversity of Australia for granted? Are we doing enough to protect our native animals and plants? Does it matter if these species die out? Who is responsible for the decline in biodiversity in Australia?	

Environmental stewards

FARMERS ARE BEST KNOWN for growing crops and raising livestock to provide the food and fibre needs for Australian families, but lately, it's all about the work they do on the farm to look after the environment.

Initiatives such as Landcare Week are opportunities to recognise the role Australian farmers play as environmental stewards and land managers says Jock Laurie, past President of the National Farmers' Federation (NFF).

"Landcare was founded more than 20 years ago by the NFF in a joint partnership with the Australian Conservation Foundation to deliver projects with positive outcomes for both the environment and agriculture," Mr Laurie said.

"Today, with support from the federal government, Landcare has grown into an environmental movement.

"Farmers are Australia's frontline environmentalists, looking after 61% of Australia's valuable land resources. After all, farmers have the most to lose if the environment becomes damaged: we simply cannot farm without healthy soils, healthy water resources and healthy air quality.

"Farmers know that good environmental outcomes and increased agricultural production go hand in hand, which is why natural resource management is a fundamental activity on Australian farms.

"According to the Australian Bureau of Statistics, 94% of farmers undertake some form of natural resource management, including planting trees and shrubs, fencing off rivers, streams and gullies to protect regrowth, and restoring wetlands.

"Australian agriculture has also led the nation in reducing greenhouse gas emissions – a massive 40% reduction between 1990 and 2006.

"And farmers are also investing financially in natural resource management. The Organisation for Economic Co-operation and Development estimates that the management of soil resources, water resources and biodiversity costs $3.5 billion in Australia annually, or around 10% of agriculture's GDP, and for every government dollar invested, Australian farmers contribute $2.60 in environmental management and protection," Mr Laurie said. – *Adapted from an NFF media release*

For more information, visit the Landcare website: landcareonline.com.au

Initiatives such as Landcare are helping Australian farmers care for the whole environment on their farms.

Activity 1 – Glossary

[Task] Define some of the terms used in Article Two, using the table provided.

Term	Definition
Landcare	
Fibre	
Environmental stewards	
Land managers	
Frontline environmentalists	
Land resources	
Agricultural production	
Natural resource management	
Greenhouse gas emissions	
Soil resources	
Water resources	
Environmental management	
Agriculture's GDP	

Activity 2 – Summarise

[Task] Answer the following questions relating to the article.

1. Who founded Landcare, and why?

2. How much of Australia's land do farmers manage?

3. Do you think it matters whether or not farmers look after the land? Why or why not?

4. What does the National Farmers' Federation say motivates farmers to care for the land?

5. List four things the article tells us that farmers are doing to look after the land.

Activity 3 – Questioning Toolkit

[Task] Write your ideas and opinions relating to each of the different types of questions.

Inspired by Jamie McKenzie's Questioning Toolkit. Further reading on questioning toolkits: McKenzie, Jamie (2000) Beyond Technology, FNO Press, Bellingham, Washington, USA. *www.fno.org/nov97/toolkit.html*

Type of question	Your ideas and opinions
Essential questions These are the most important and central questions. They probe the deepest issues that confront us and can be difficult to answer. **Questions** What is land management? What is involved in managing the land? Why does the land need to be managed?	
Subsidiary questions These questions help us to manage our information by finding the most relevant details. **Questions** What role do cattle and sheep farmers play in land management? Is it important that farmers play this role? What do farmers need to do to effectively manage the land?	

Type of question	Your ideas and opinions
Hypothetical questions Questions designed to explore the possibilities, the 'what ifs?' They are useful when we want to test our hunches. **Questions** What if cattle and sheep farmers only allowed stock animals on their land, and got rid of all other animals? What if farmers removed all plants from their land except the ones they grew as pastures?	
Provocative questions Questions to challenge convention. **Questions** Do cattle and sheep farmers have a moral obligation to look after Australia's farmland and all the living things on it? Should every type of land owner be held responsible for the health and biodiversity of their land?	

Farmer initiatives

Farm case study 1: 'Bangor', Tasmania
Owners: Matt and Vanessa Dunbabin

THE ENVIRONMENT AT Bangor farm on southeast Tasmania's Forestier Peninsula – covered in native grasslands, home to endangered Tasmanian devils and bordered by 35 km of pristine coastline – is in Matt Dunbabin's blood.

The Dunbabins have farmed Bangor – where Matt now lives with his wife, agricultural scientist Vanessa Dunbabin, and their three children – for five generations, since the 1890s when the property ran sheep and sold possum and wallaby furs.

Today, Bangor runs superfine wool Merino sheep and prime beef and lamb over 6200 hectares, but with a 'light footprint' philosophy. More than 5000 hectares of Bangor are covered with unsown native forests and grasslands, where grazing is so light it is measured in hectares-per-sheep. In addition, 2100 of those hectares are permanent conservation reserves, some of which, such as ecologically sensitive wetlands, are isolated from grazing altogether.

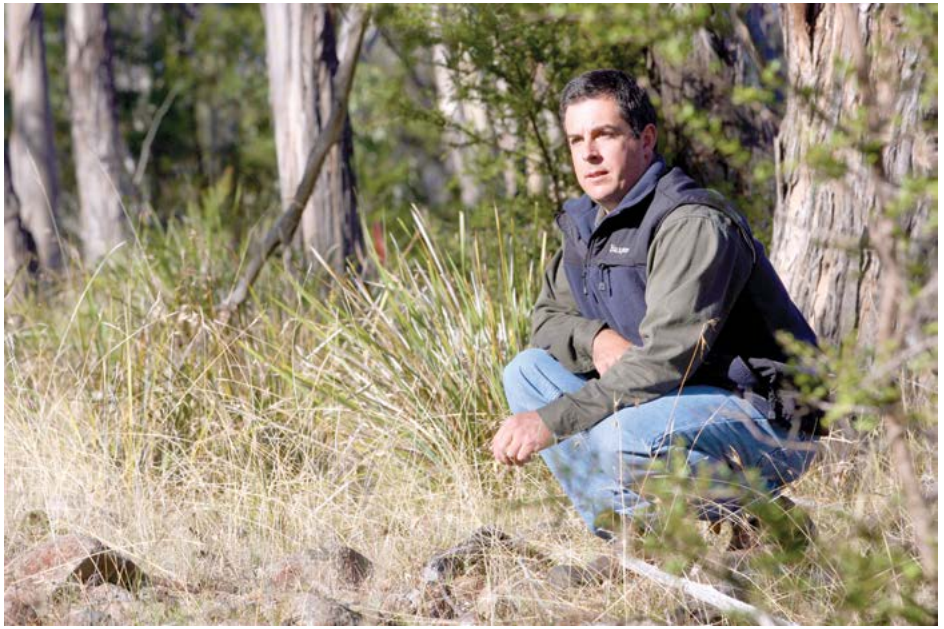
"It's not always easy, but it is rewarding," says Dunbabin of the family's long-running sustainable approach to land management. And while there are compromises to be made in limiting grazing for conservation purposes, there are also practical benefits. "The plus side is that on the native pastures we don't get internal parasites like worms," he says. "We don't get flies, we don't have to spend money on fertilisers and there aren't many weeds – there isn't the space for the weeds to get going."

The balancing act, however, is conserving the environment while maintaining an operational farm. Much of Bangor's native grasslands, Dunbabin points out, could end up being developed as real estate if they weren't incorporated into the farm. That means production is driven harder on the remaining 1400 hectares of sown pastures, including higher stocking rates and the use of fertilisers and irrigation. "If we can keep a viable business, it helps take the pressure off the native country we've got here," he says.

Bangor is also the site of several research programs from the University of Tasmania and the Tasmanian Department of Primary Industries, Parks, Water and Environment. Studies range from monitoring native bird populations and feral cats, to archaeological findings at a nearby historic whaling station. Bangor is also partnered with the Save the Tasmanian Devil program, which monitors the spread of facial tumours among the property's sizable local population of the endangered carnivorous marsupials.

There was no specific catalyst or epiphany that put sustainable land management at the centre of Bangor's philosophy – it's simply always been done that way. "There are areas that could have been cleared and weren't, back before my time," Dunbabin says. "Why they weren't, I don't know, but we're now the beneficiaries of that."

Dunbabin is also keen to point out they're not alone in their approach. "We're no Robinson Crusoes," he says. "There are lots of people out there who have been doing similar stuff for generations, the same as us." – *Gemma Black*



On his farm in Tasmania (below), Matt Dunbabin (above) grows sheep and cattle while maintaining extensive native bushland.

M. DUNBABIN

Farmer initiatives

Farm case study 2: Anna Plains, Western Australia
Owners: David Stoate and Helen Campion

ON ANNA PLAINS Station, we run 16,000 Brahman cattle on the property, which is 380,000 hectares in size.

We are a family-run station and have the ocean on one side and the desert on the other. For our cattle business – our livelihood – to survive, we have to look after the rangelands. They go hand in hand. We can't successfully raise cattle if we don't look after the environment.

Our cattle graze on natural rangelands mostly behind fences, with the biggest paddock approximately 10,000 hectares. It's a pretty big area so we use photo-monitoring sites across the station to monitor rangeland conditions over time. For short-term planning, we use forage budgets to work out how long feed supplies will last and how many cattle can graze in a particular area.

We have rainfall records that date back for 105 years. They show in the past 30 years the average rainfall has increased, but we still have dry years. In the past 35 years, compared to the first 70 years, the rain has increased 30%.

At Anna Plains, we are very lucky to have wetlands adjacent to the property protected and listed under the Ramsar Convention as an international site of importance.

Every year, migratory waders and waterbirds visit the wetlands, the beach and also feed on some of the grasslands near the coast which are a feature of Anna Plains Station. They migrate to Siberia in April and May. Anna Plains is a real safe haven for the birds because the habitat is in pristine condition, compared to others which are being destroyed on their flight path.

The good news story is that the cattle and birds coexist well. The cattle feed on the grass, and the birds prefer it to be kept low. It means that birds of prey can't creep up on them. Approximately 80% of one wader bird species, the Oriental Plover, feed on the grasslands of Anna Plains.

The opportunities on our property and for the region are enormous, whether it's to increase beef production or pursue other opportunities to turn off young cattle to suit new markets, should they arise.

We believe that being pastoralists is an occupation that allows us to care for the environment, put food on people's tables and generally leave the world a better place than when we found it.

– Meat & Livestock Australia

MEAT & LIVESTOCK AUSTRALIA

Activity 1 – Glossary

[Task] Define some of the scientific terms used in the case studies, using the table provided.

Term	Definition
Pristine	
Light-footprint philosophy	
Ecologically sensitive	
Sown pastures	
Stocking rates	
Sustainable land management	
Rangelands	
Photo monitoring sites	
Forage budgets	

Term	Definition
Ramsar Convention	
Wetlands	
Migratory waders	
Grasslands	
Coexist	
Aquaculture	
Horticulture	
Pastoralists	

Activity 2 – Summarise

[Task] Draw a labelled sketch to represent the Dunbabin's land and how it is structured to support native species as well as stock animals. Make sure you include coastline, sown pastures (both lightly grazed and heavily grazed), unsown forest and grassland, conservation reserves, wetland, stock animals and native animals.

Your sketch:

Explain (article three)

[Task] Answer the following questions relating to the case studies.

1. In case study 1, farmer Matt Dunbabin says of farm management; "It's not always easy, but it is rewarding."

a) What do you think might be rewarding about managing the farm the way it's described in this article?

b) What do you think might be some of the challenges that make it "not always easy"?

c) What explanation is given for why the farm is managed the way it is?

2. In case study 2:

a) What is the farmers' explanation for why they look after the rangelands?

b) Which native animals do the farmers mention visit their properties?

Explain (article three)

c) Is the property an important place to these animals? Why or why not?

d) What example do the farmers give of how the stock and wildlife live well together?

3. Having read both case studies, what is your impression of how these farmers view their role as landowners?

Activity 3 – Questioning Toolkit

[Task] Write your ideas and opinions relating to each of the different types of questions.

Inspired by Jamie McKenzie's Questioning Toolkit. Further reading on questioning toolkits: McKenzie, Jamie (2000) Beyond Technology, FNO Press, Bellingham, Washington, USA. *www.fno.org/nov97/toolkit.html*

Type of question	Your ideas and opinions
Essential questions These are the most important and central questions. They probe the deepest issues that confront us and can be difficult to answer. **Questions** Can you conserve the environment while maintaining an operational, profitable cattle and sheep farm? Is it practical to do both? How can this be achieved?	
Subsidiary questions These questions help us to manage our information by finding the most relevant details. **Questions** What sorts of things are being done by cattle and sheep farmers to conserve biodiversity on their land? Why are they doing these things? Have they always done them?	

Type of question	Your ideas and opinions
Hypothetical questions Questions designed to explore the possibilities, the 'what ifs?' They are useful when we want to test our hunches. **Questions** What if cattle and sheep farmers did nothing to look after biodiversity on their land – what might be the consequences? If farmers weren't allowed to remove native trees or animals from their land how would it make a difference to biodiversity on their property? What if you were a farmer - what would you do with the biodiversity on your land?	
Provocative questions Questions to challenge convention. **Questions** Is it reasonable to expect cattle and sheep farmers to be both business people and environmental stewards? Should we expect all types of businesses to look after the environment? Does everyone have a role to play in caring for their local environment?	

Activity 5 – Bringing it all together

1. Create a mind map in the space below to show the main topics the three articles address, and how the articles are related to one another.

2. List five issues you have learnt about biodiversity and cattle and sheep farming from the articles.

_____

_____

_____

_____

_____

_____

_____

_____

3. List five questions you have after reading the articles.

_____

_____

_____

_____

_____

_____

_____

_____

About the Refraction Science Matrix

What is the Refraction Science Matrix?
A learning matrix such as the Refraction Science Matrix is a flexible classroom tool designed to meet the needs of a variety of different learning styles across different levels of capabilities. Students learn in many different ways; some are suited to hands-on activities, others are strong visual learners, some enjoy intellectually challenging, independent hands-off activities, while others need more guidance. The matrix provides a smorgasbord of science learning activities from which teachers and/or students can choose.

Can I use the matrix for one or two lessons, or for a whole unit of study?
Either! The matrix is designed to be time flexible as well as educationally flexible. A time frame for each activity is suggested on the matrix. Choose to complete one activity, or as many as you like.

Is there room for student negotiation?
Yes! Students can be given a copy of the matrix and choose their own activities, or design their own activities in consultation with their classroom teacher.

Can I use the matrix for a class assessment?
Yes! You can set up a point system – perhaps one lesson equals one point. Students can be given a number of points to complete. If they choose less demanding activities, they will have to complete more of them.

What do the column headings mean?

1. Read and revise
Designed to enhance student comprehension of information.
2. Read and relate
Gives the student the opportunity to apply or transfer their learning into a unique format.
3. Read and review
Requires the more challenging tasks of analysing and/or assessing information to create and express new ideas and opinions.

What do the row headings mean?

Row heading	Description of activity
Scientific procedure	Hands-on activities that follow scientific method. Includes experiments and surveys. Great for kinaesthetic and logical learners, as well as budding scientists.
Science philosophy	Thinking about science and its role in society. Includes discussion of ethical issues, debates and hypothetical situations. An important part of science in the 21st century.
Being creative with science	For all those imaginative students with a creative flair. Great for visual and musical learners and those who like to be innovative with the written word.
Science time travel	Here we consider scientific and technological development as a linear process by looking back in time or travelling creatively into the future.
'Me' the scientist	Personalising the science experience in order to engage students more deeply.
Communicating with graphics	Using images to communicate complex science ideas.
ICT	Exploring the topic using computers and the Internet.

Elaborate (activity matrix)

	1. Read and revise	2. Read and relate	3. Read and review
Scientific procedure	What biodiversity do you have on your school grounds? Explore the variety of living things around your school. See Linked Activity 1.	What effect does salinity have on the germination and growth of different plants? See Linked Activity 2.	Design, conduct and communicate the results of an experiment you have designed that does one of the following: ■ Provides information about the biodiversity of your garden or a local habitat. ■ Tests a factor/variable that is intended to increase biodiversity in your backyard or schoolyard, such as the introduction of a birdhouse or a native plant.
Science philosophy	The Bangor farm is described as having a 'light footprint philosophy'. What do you think this means? Is it a good philosophy to have?	What do you think the statement 'Many farmers have the philosophy to work with the land, not against it' means? Can you think of some examples of working with the land and working against the land? What might be the benefits and drawbacks of each of these approaches?	Do farmers have an ethical obligation to maintain biodiversity on their farms no matter how much it costs them economically? How much financial or practical assistance from the government or NGOs should farmers receive if they need help maintaining biodiversity? Write a set of protocols or guidelines that farmers can follow to help them either increase biodiversity themselves or seek help to assist them increase biodiversity.
Being creative with science	Create a poster or pamphlet to promote to farmers one or more of the methods of increasing biodiversity mentioned in the articles.	Weed control is an important part of managing a farm. Consider the following information on maintaining a balance between 'tree and grass.' *mla.com.au/research-and-development/Grazing-pasture-management/native-pasture/tree-grass-balance*. Create a skit, song or video that illustrates this information in a fun or interesting way.	Search the Internet and books for artwork that is inspired by biodiversity. Here are a couple of videos to get you started. *youtube.com/watch?v=F6PaMZTx0c4* *youtube.com/watch?v=wLmL7Y_bkIw&NR=1* Pretend you are an art curator working in a gallery who wants to promote biodiversity by having an exhibition. Choose 10 pieces (eg, videos, painting, sculpture) you would display and write a brief description to go next to each artwork. You can also say why you chose this piece for the exhibition.
Science time travel	Use information in the articles to create a 'before and after' drawing of a farm that has increased its biodiversity. Give the drawings to someone else and ask them to list the differences that show biodiversity has increased.	Research and report on some of the farming practices carried out in the 1800s and early 1900s that caused a decline in biodiversity. What were some of the mistakes farmers made and how have procedures changed today so that we do not continue to reduce biodiversity? How have we learned from our mistakes? Use at least two examples of procedures that have changed over time for the better.	Imagine it is the year 2040 and it is the evening of the annual environmental stewardship awards. The winning farmer will be announced and then whisked away on a year of travel to show other farmers how to maintain and protect the land they farm. Write a story showing how two farmers have competed for this prestigious award and how one of them just manages to beat the other on a count back. What environmental practices did the winning farmer do to win this sought-after award?
'Me' the scientist	You are an expert on natural resource management. Use the information in the articles to design an information package to inform farmers how they might protect, manage and enhance biodiversity on grazing farms by retaining, restoring and revegetating. Include ideas such as planting tree belts, having designated conservation areas on their land and improving fencing to keep out feral animals.	You are a science journalist. Contact someone from your local Landcare group and interview them on the work they do related to improving biodiversity in your area. Present your interview as a podcast, skit or magazine article.	You are a Landcare scientist. Go to the Junior Landcare Grants Program web page (juniorlandcare.com.au/grants-2). Design a project either individually or as a class that will increase biodiversity in your local area or school and then apply to Landcare for a grant to help you carry out your project. Keep a photo diary of your journey to make your biodiversity idea a reality.
Communicating with graphics	In the first article it says that in 2001, farmers planted 20.6 million tree seedlings compared with nine million in 1991. Graph these two results to visualise them.	Go to *phylogame.org/wp-content/uploads/2012/07/PHYLOBEATYDECK2012.pdf* and print the cards so that you can play the game. What did you learn? How could the game be improved?	Create a logo for the National Farmers' Federation to promote its role as environmental protector. Describe your inspiration for the logo, such as why you chose a specific image or phrase to include.
ICT	Use quiz-writing software to write a series of questions that will test your fellow students' understanding of one of the articles about farming and biodiversity.	Create a prezi showing at least five different introduced pest species. Examples could include wild dogs, feral cats, feral pigs, prickly acacia, and lantana. Describe the pest, the damage it causes, the reason it was introduced, and the measures taken to reduce its impact without reducing local biodiversity.	Write an app (or the details for an app) that farmers could use to record and monitor the biodiversity on their farms. Include options to store photo images of the variety of different organisms being logged, and to track their population size over time.

Activity 1

BIODIVERSITY IN YOUR SCHOOLYARD

AIM

To find out if the amount of vegetation affects the biodiversity of insects and arachnids ('bugs') at your school.

INTRODUCTION

Many factors affect the variety of living things that inhabit a particular habitat. The more farmers understand the habitat of a particular organism (as well as the organism itself), the more chance they have of successfully managing that organism on their farm. In this activity, you will examine the effect of vegetation on biodiversity. Remember that the animals you are working with in this investigation must be placed back where you found them once you have finished counting them. Take all precautions necessary so that you do not harm them during this activity.
Note: if you live in an area with snakes, insects or spiders that give harmful bites, you may want to take an identification chart with you. DO NOT TOUCH HARMFUL SNAKES, INSECTS OR SPIDERS. If you do get a bite, consult your teacher immediately.

HYPOTHESIS

Which area in the school do you think will have the greatest biodiversity of bugs, and which do you think will have the least biodiversity?

MATERIALS

- Approximately 100 clear petri dishes (three or four per student)
- Two trays or containers such as plastic drawers to hold 50 petri dishes each

METHODS

1. Identify two areas around the school grounds that could be appropriate to use in this investigation. Make sure one area has no (or very little) vegetation and the other has plenty of vegetation (such as under a tree on a grassy oval).

2. Divide the petri dishes into two groups of 50. Place one group of 50 in a container labelled 'vegetation' and the other 50 in a container labelled 'no vegetation'.

3. Go to the area with little or no vegetation and humanely collect a bug in each of the 50 petri dishes. Return each petri dish to the container.

4. Go to the area with lots of vegetation and humanely collect a bug in each of the 50 petri dishes. Return each petri dish to the container.

5. Back in the classroom stack all the petri dishes with each kind of bug from the 'no vegetation' area one on top of the other. For example, make a stack of petri dishes with ants (if you found ants) and another with centipedes (if you found centipedes) and so on for each species of bug you found.

6. Repeat step five for the 'vegetation' area. You will notice you have 'built' two column graphs.

7. When you have completed the Results section of this investigation, return all bugs to the area where you found them.

RISK ANALYSIS

Risk	Precaution	Consequence
Bite from an insect or spider	• Collect the bug directly into petri dish • Wear gloves	Stinging sensation, itching, allergic reaction

RESULTS

1. Make a column graph of the number of each species of bug found in the two areas.

2. Write a sentence or two summarising the results shown in the graph.

DISCUSSION

1. Define the term 'biodiversity'.

2. What effect does the presence of vegetation have on the number of bugs present at your school?

3. What effect does the presence of vegetation have on the biodiversity of bugs present at your school?

4. Do you think that a large number of a single species or a large number of different species (biodiversity) is a better environmental scenario? Give an example to justify your choice of response.

5. If you wanted to conserve biodiversity in your schoolyard, what advice would you give your principal?

6. List any other environmental differences or variables in the two areas where you collected bugs (eg, amount of shade).

a. Which of the variables you have identified in the previous question do you think could also influence the biodiversity of bugs you collected?

b. Suggest ways you could control these variables when trying to identify the effect of amount of vegetation as the sole variable.

c. Suggest ways you could independently investigate the effects of these other variables on biodiversity.

7. Why is important to return the bugs you counted in this investigation back to the place you found them?

8. Why do you think it is important for scientists not to harm living things or their habitat when conducting investigations like the one you carried out today?

Activity 2

THE EFFECT OF SALINITY ON THE GERMINATION AND GROWTH OF PLANTS

AIM
To investigate the effect of salinity on the germination and growth of plants.

INTRODUCTION
The articles describe farmers as Australia's frontline environmentalists because they look after 61% of Australia's valuable land resources. Farmers cannot farm without healthy soils, healthy water resources and healthy air quality. In this activity, you will examine soil salinity – one aspect of a healthy soil. How much salt can a plant tolerate before it cannot germinate and grow optimally? You will set up an experiment to find out how much salt is too much by investigating which concentration of salt adversely affects the plant.

HYPOTHESIS
State what you think will happen to the germination and growth of a plant with too much salt.

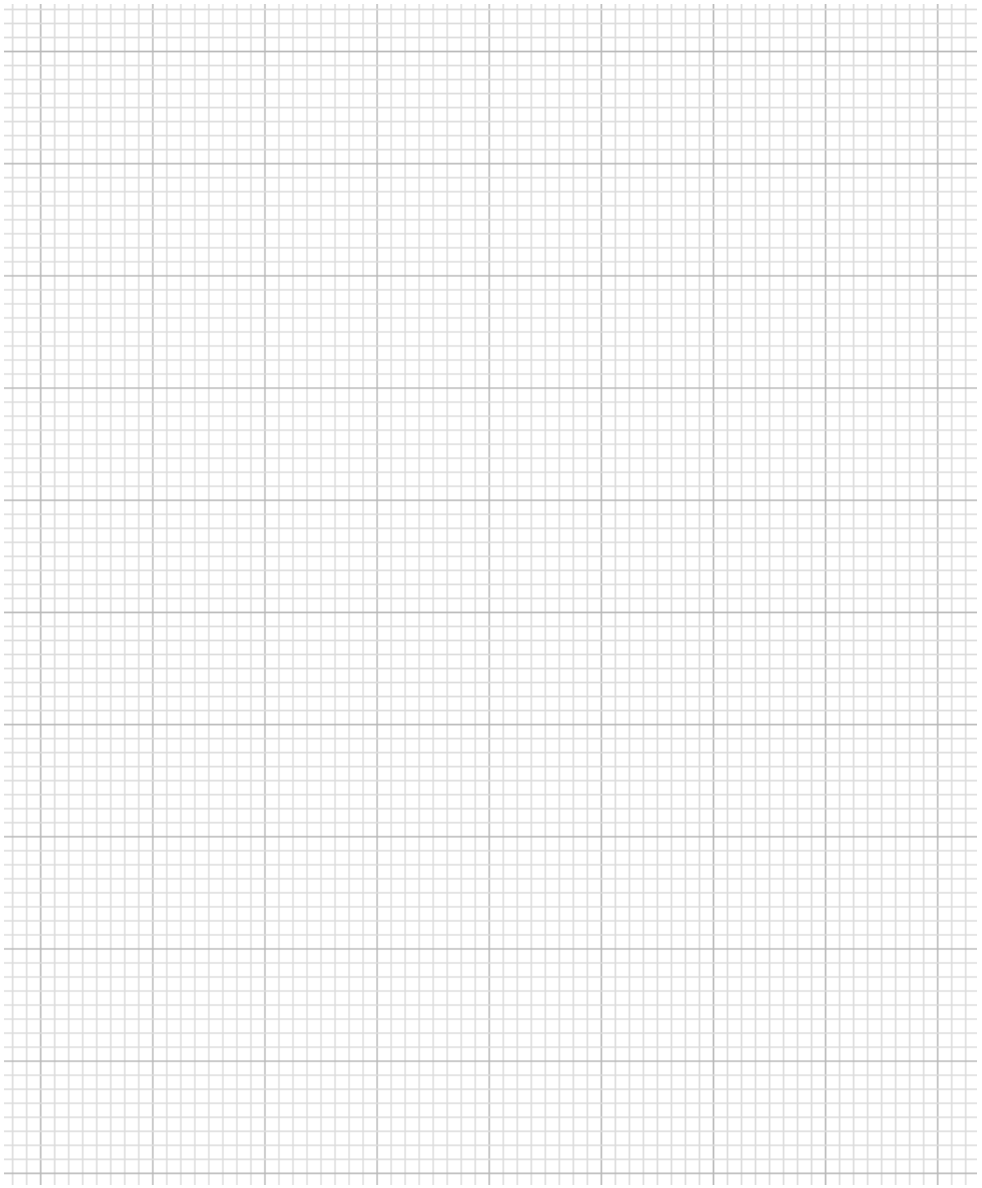
MATERIALS
- Salt
- Cotton wool
- Petri dishes
- Water

METHOD
(Write your methods in a numbered list to show how you will go about testing your hypothesis.)

1.

RISK ANALYSIS
Record any risks associated with your method and suggest how you will avoid them.

Risk	Precaution	Consequence



RESULTS

1. Design a table in the space below to record your results.

2. Graph the data you collected on the grid at left.

DISCUSSION

1. What was your independent variable, the one you changed?

2. What was your dependent variable, the one you measured during the experiment?

3. Which variables did you have to keep constant throughout the experiment so that it was a fair test?

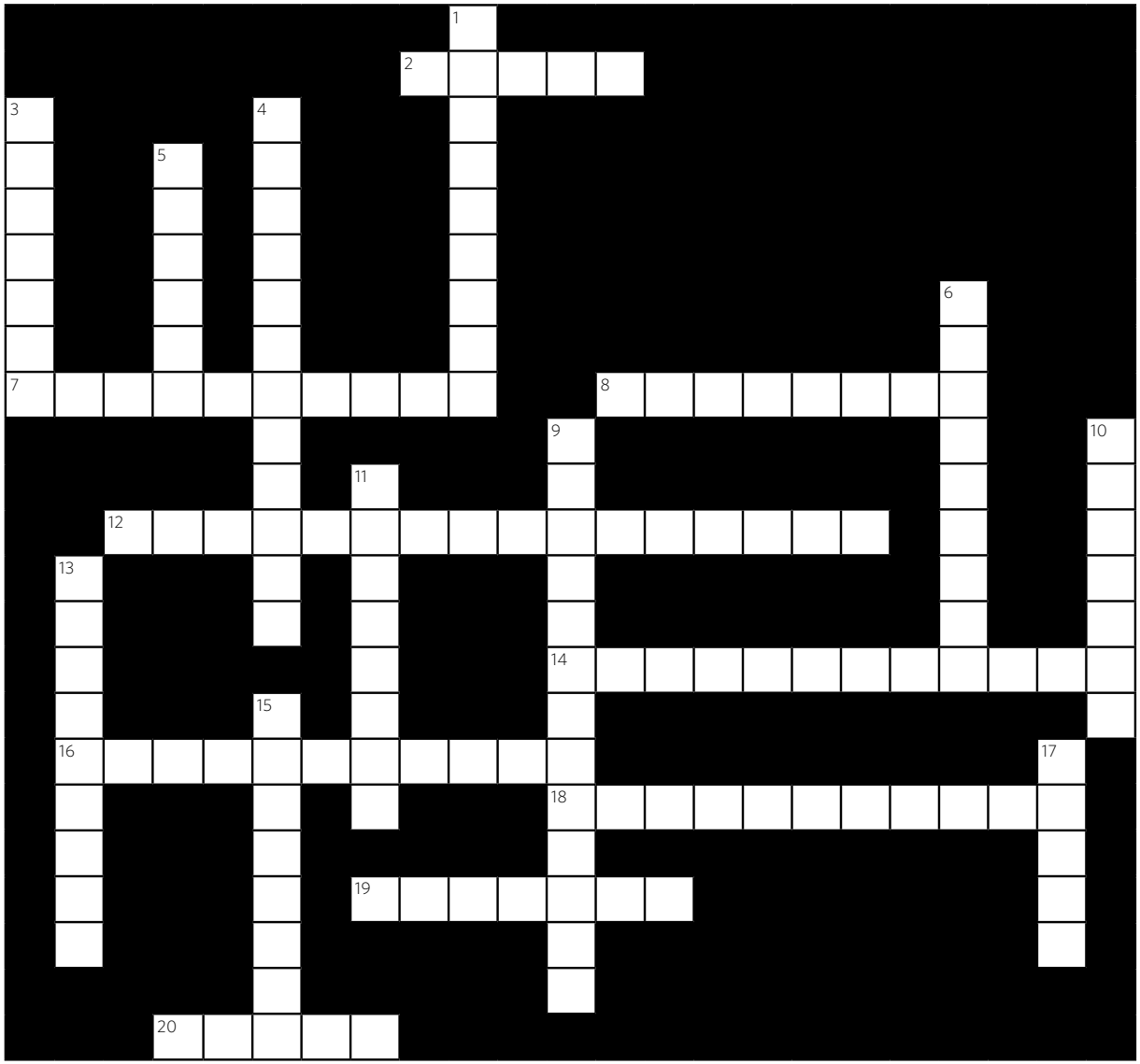
4. Identify the control in your experiment.

5. Suggest any difficulties you had while conducting this investigation and how you overcame them.

CONCLUSION

(Write a conclusion that responds to your aim and summarises your results.)

Crossword



Activities to enable students to show what they know about biodiversity and land care in the cattle and sheep industries, and evaluate their learning.

Across

2. Plants that grow where they are not wanted.
7. To replace trees or bushland that has been cleared.
8. An environmental movement established by farmers and the Australian Conservation Foundation.
12. A person who is concerned about the protection of the environment.
14. Preservation or protection of the natural environment.
16. Capable of being continued with minimal long-term effect on the environment.
18. The business of producing crops and raising livestock.
19. To live in the same place at the same time.
20. Insects and other animals considered to be a nuisance to humans.

Down

1. Chemical used to kill weeds.
3. The owner of a large property on which sheep or cattle graze.
4. The variety of all lifeforms on Earth and the ecosystems they live in.
5. Originating and living naturally in an area or environment.
6. A strip of soil planted with trees.
9. Removing trees and other vegetation from the land.
10. Left over.
11. Land covered with woods or trees.
13. Animals raised for human consumption.
15. Land covered with plants suitable for grazing animals, especially cattle or sheep.
17. Having returned to an untamed state after being domesticated.

Answers on page 49

Biodiversity DIY quiz

1. Ask each student to call out a word or term that relates to the topic (eg, revegetation). Record these on the board.

2. Each student should pick three terms from the board and write a definition for each.

3. Each student should pick another three terms from the board, then write a paragraph about the cattle and sheep industry that uses each of these words.

4. Students create their own concept map, or some other type of diagram, to show what they have learned about biodiversity and farming. They are to use as many words or terms from the board as possible, and show the connections between these.

Class debate

1. Choose one of the following questions as the topic for a class debate:

   a) Cattle and sheep farmers have a vital role to play in biodiversity conservation.

   b) There is no need for cattle and sheep farmers to look after any species other than the ones they are farming.

   c) It is unrealistic to expect cattle and sheep farmers to protect biodiversity on farm land.

2. Divide the class into two groups. Group 1 will debate the affirmative and Group 2 will debate the opposing view.

3. Appoint an adjudicator, or an adjudicating team to decide which debating team presented the most compelling argument.

Group presentations

1. Place students into small groups, in which they will work to prepare and give a short presentation to the class. (Each member should have a few minutes each to talk).

2. Allocate a topic to each group, or have them choose their own, based on the activities they have been doing in this unit, for example: biodiversity on farms; farmers as environmental stewards; natural resource management on farms; case studies of Australian farms.

3. Give each group a mark for their overall presentation, and each group member an individual mark for their part of the talk.

Personal review of unit

Personal summary	**Where to now?**
Make a dot-point summary, or a mind map, of all the things you learned during this unit of work. Highlight the things you found the most interesting.	Write five questions that have come up while you have been studying this unit of work, to which you would like to know the answers.
Something philosophical	**Something political**
Think of two ethical issues that came up during this unit of work, and propose some ideas about how these issues might be addressed.	If you were a leader in Australia today, what changes would you make to ensure our country's biodiversity was protected for the future?

Crossword answers