Southwest edition

Be a Bush Scientist

Written and designed by Felicity Bradshaw

Produced by the Centre for Learning Technology,
The University of Western Australia, for the SPICE program

spice

Acknowledgements

Be a Bush Scientist was designed and written by Felicity Bradshaw. It was inspired by researching how animals function in their natural environment, under the tutelage of Professor Don Bradshaw at The University of Western Australia ("UWA"). It has benefited from his many suggestions and contributions.

For more information, or assistance implementing *Be a Bush Scientist*, contact Felicity through info@honeypossum.com.au

The program owes its inception to two Primary School teachers: Angela Spry, Year 1 teacher at Christ Church Grammar School, who took on the project in its formative year; and Jennifer Russell, Year 1 teacher at Woodlands Primary School, who taught the expanded program in her biological sciences module. It has been guided by Jennifer's expertise in teaching science to young children.

Translating the program into a format suitable for the curriculum was undertaken by Assoc. Prof. Christine Howitt at the Graduate School of Education, UWA.

Others who have contributed to this program include Professor Stephen Hopper, Professor Kingsley Dixon and Professor Hans Lambers, all from UWA.

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Bush scientists
photo by Jennifer Russell

Contents: *Be a Bush Scientist*

Appendices

Digital resources for *Be a Bush Scientist* are available on CD-ROM or USB. They include electronic copies of this teacher guide, its appendices and audiovisual resources (PowerPoint presentations and video).

Digital resources

		folder on CD-ROM or USB
preparation	Licence to take fauna	forms
	My bush notebook	templates
Part 1: Bush story	Introducing honey possums	presentations
	Honey possum feeding on bottlebrush	video
Part 2: Exploring plants	Introducing plants	presentations
	Bush library	library
	Bush trees	templates
Part 3: Exploring animals	Introducing animals	presentations
	What invertebrate is it?	worksheet
Part 4: Exploring leaves and litter	Introducing leaves and litter	presentations
Part 5: Flowers	Introducing flowers	presentations
	Pollen library	library
Part 6: Food	Introducing food	presentations
	Honey possum feeding on honey solution	video
	Honey possum feeding on jug flower	video
Part 7: Connections	Introducing connections	presentations
	Bush Scientist certificates and badges	templates

Background

Be a Bush Scientist is an integrated science program, designed for students in Years 1 to 4, that demonstrates values of the natural environment and introduces concepts of biodiversity and sustainability. The program has been written for the study of remnant banksia woodland, but is adaptable to other types of native bush, or areas of a school that contain some natural habitat.

What is the value of natural bush? Why do we need to conserve it?

The level of biodiversity within the bush is a barometer that measures the health of not just the bush, but of our environment. That is its value.

We need to conserve it because elements within the bush play vital roles in our survival: purification of our water; pollination of our crops; reduction in the level of carbon dioxide; and preventing salt from poisoning our soils are a few important examples.

There is great need for biological research into our natural environment. This program, *Be a Bush Scientist*, uses the honey possum as an example of an animal whose existence depends on plants in its habitat. Other animals may be substituted. The program guides young children through basic steps of environmental investigation, ideally in remnant banksia woodland near primary schools. If these 'outdoor classrooms' are not available, however, the program will be successful in any nearby natural bush.

Using methods of observation, recording and analysis, students act as scientists to evaluate basic elements of the bush: plants, animals and litter. The extent to which these elements are explored depends on students' year level and relevant content of the Australian Curriculum: Science (specifically science understanding for biological sciences).

Students progressively recreate in their classroom the main components of an area of bushland through the construction of an 'ecogram'. This provides a model for understanding how the bush 'works'. Each component in the ecogram is physically connected with another, based on relationships such as: producer and consumer (leaf and caterpillar, worm and kookaburra …); parts of life cycles (tree-leaf-litter, flower-pollinator-seed …); or habitat (litter-beetle). In this way, the bush is represented visually as a single 'organism', or ecosystem, with each element dependent upon another. The final lesson is a step-wise deconstruction of the ecogram by students to emphasise this dependency and demonstrate the vital role of pollination in sustaining the natural world.

Be a Bush Scientist covers all three strands of the Australian Curriculum: Science. The program has strong links to science, literacy, numeracy, the arts, sustainability and ethical behaviour.

The program also recognises the spiritual significance of the bush for Indigenous Australians and is respectful to their knowledge, *kardadjiny*, of our natural environment.

Australia acknowledges the significant contributions of Aboriginal and Torres Strait Islander people locally and globally. Aboriginal communities maintain a special connection to and responsibility for Country/Place throughout all of Australia. Their ways of life are uniquely expressed through ways of being, knowing, thinking and doing. Aboriginal peoples have unique belief systems that spiritually connect them to land, sea, sky, waterways, flora and fauna

There are many opportunities within the program to involve local Elders in providing their perspective on the value and importance of natural bush.

Science understandings (biological sciences)	Science inquiry skills	Science as a human endeavour
• trapping and identifying animals • simple classification and understanding of a dichotomous key • processes of photosynthesis, pollination, seed production and plant life-cycle • producers and consumers • nature of an ecosystem • concept of biodiversity	• planning investigations and predicting outcomes • conducting investigations • developing graphical representations of data • analysing and interpreting data • communicating findings in a variety of representations	• a mechanism for making predictions and describing patterns and relationships • a working model for the practice of science • knowledge and a respect for the natural environment • development of a sense of responsibility for a community asset

Learning pathway

The program is structured around a constructivist model, based on the 5-Es, where teachers may:

- **Engage** students interest in the Australian bush through a story about honey possums;
- provide opportunities for students to **Explore** plants and animals in the bush;
- guide students to **Explain** how various components of the bush are interconnected;
- **Elaborate** on ideas presented through considering what happens if components of the bush are removed; and
- **Evaluate** students' progress throughout the program.

	PURPOSE	DESCRIPTION
Part 1: Bush story	ENGAGE	This resource is intended to engage students' interest in the bush, by learning about an unusual Western Australian marsupial: the honey possum.
Part 2: Exploring plants	EXPLORE	Students explore the bush by investigating plants, animals, bush litter and their interdependence. They analyse data and construct an installation (ecogram) that represents an area of bush.
Part 3: Exploring animals	EXPLORE	
Part 4: Exploring leaves and litter	EXPLORE	
Part 5: Flowers	EXPLAIN	Students learn about the life cycle of plants and the role of pollinators.
Part 6: Food	EXPLAIN	Students learn about the role of plants as producers of food; and animals as consumers of food.
Part 7: Connections	ELABORATE	Students visually represent connections between components of the bush on an ecogram. They predict consequences of removal of elements from this interconnected web.

Technical requirements

The teacher guide requires Adobe Reader (version 5 or later), which is a free download from www.adobe.com.

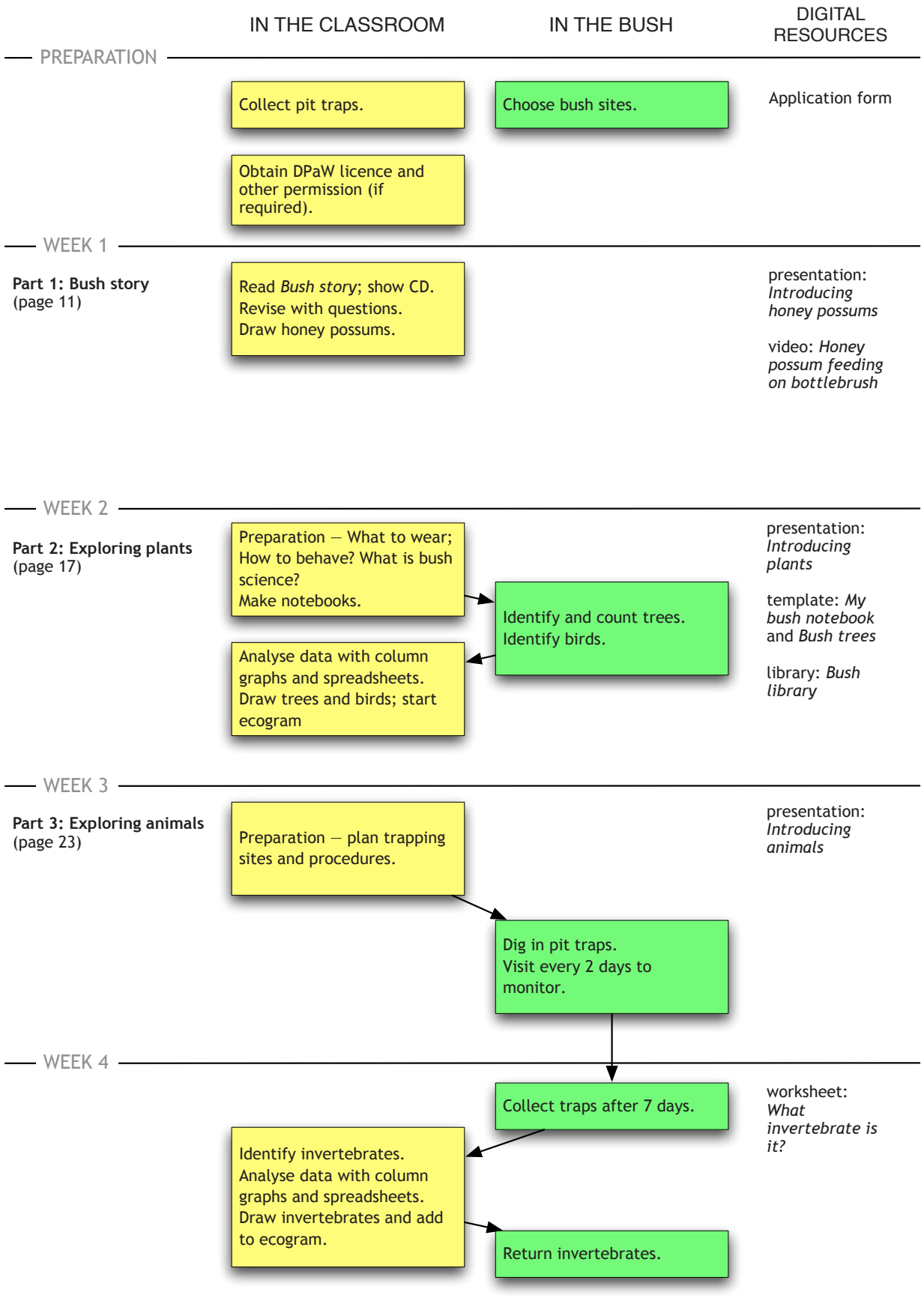
Presentations are supplied in Microsoft PowerPoint and PDF format. Templates and worksheets are supplied in Microsoft Word and PDF format.

A modern browser (eg Internet Explorer 7 or later, Google Chrome, Safari 4.0+, Opera or Firefox) is required to view the video. This is a free download from www.apple.com/quicktime.

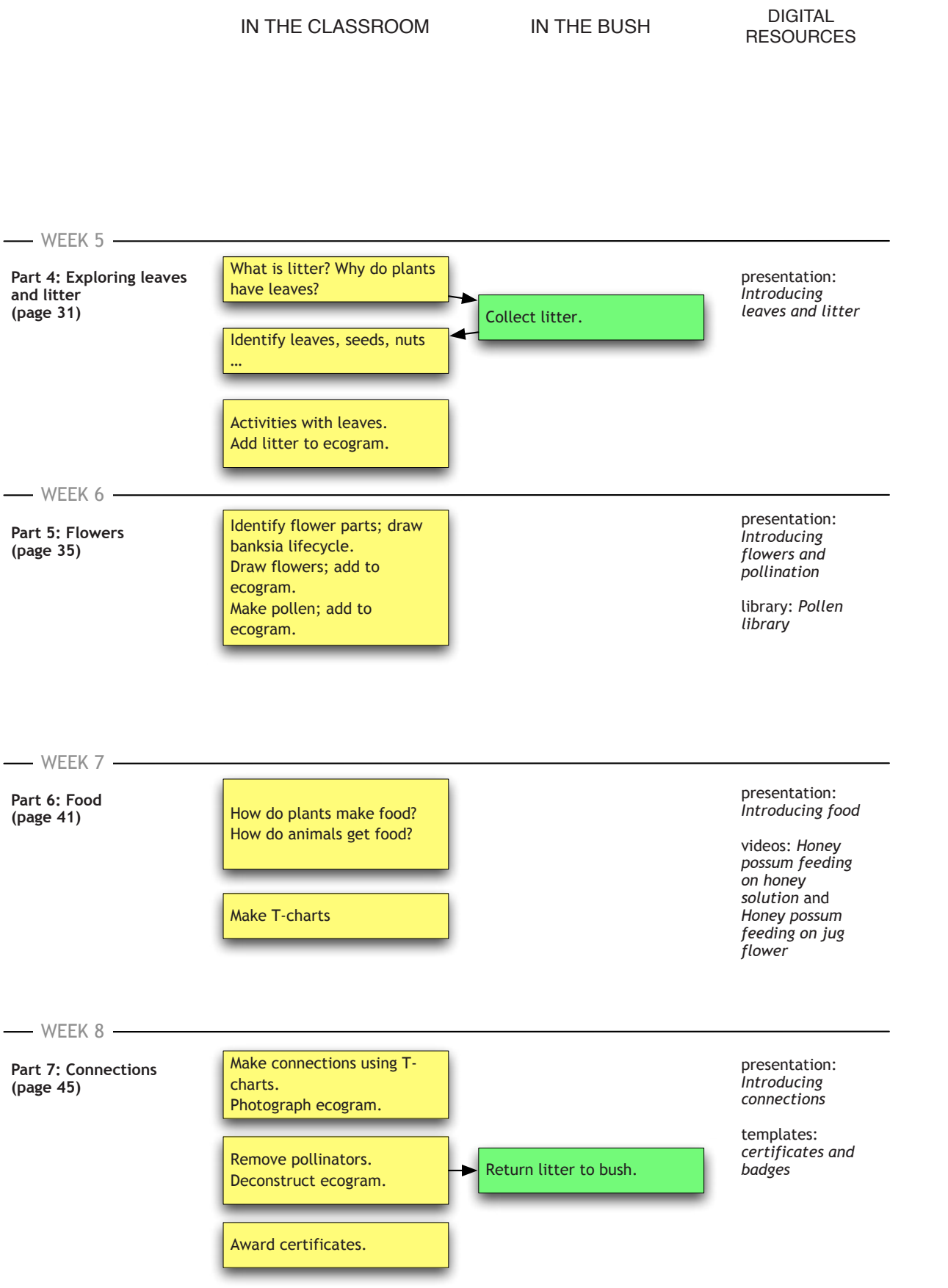
Links to Australian curriculum

SCIENCE UNDERSTANDING (YEAR 4)	PARTS
Biological sciences — Living things have life cycles (ACSSU072) • describing the stages of life cycles of different living things such as insects, birds, frogs and flowering plants • comparing life cycles of animals and plants • recognising that environmental factors can affect life cycles such as fire and seed germination	1, 2, 3, 5, 6
Biological sciences — Living things, including plants and animals, depend on each other and the environment to survive (ACSSU073) • investigating how plants provide shelter for animals • investigating the roles of living things in a habitat, for instance producers, consumers or decomposers • observing and describing predator-prey relationships • predicting the effects when living things in feeding relationships are removed or die out in an area • recognising that interactions between living things may be competitive or mutually beneficial	1, 2, 3, 4, 5, 6, 7
SCIENCE AS A HUMAN ENDEAVOUR (YEAR 4)	
Nature and development of science — Science involves making predictions and describing patterns and relationships (ACSHE061) • exploring ways in which scientists gather evidence for their ideas and develop explanations	2, 6
Use and influence of science — Science knowledge helps people to understand the effect of their actions (ACSHE062) • exploring how science has contributed to a discussion about an issue such as loss of habitat for living things or how human activity has changed the local environment	7
SCIENCE INQUIRY SKILLS (YEAR 4)	
Planning and conducting: Safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate (ACSIS066) • discussing and recording safety rules for equipment as a whole class • making and recording measurements using familiar formal units and appropriate abbreviations, such as seconds (s), grams (g), centimetres (cm) and millilitres (mL)	2, 3
Processing and analysing data and information: Use a range of methods including tables and simple column graphs to represent data and to identify patterns and trends (ACSIS068) • identifying and discussing numerical and visual patterns in data collected from students' investigations and from other sources • using provided graphic organisers to sort and represent information • discussing with teacher guidance which graphic organisers will be most useful in sorting or organising data arising from investigations	2, 3
Processing and analysing data and information: Compare results with predictions, suggesting possible reasons for findings (ACSIS216) • discussing how well predictions matched results from an investigation and proposing reasons for findings • comparing, in small groups, proposed reasons for findings and explaining their reasoning	2, 3
Communicating: Represent and communicate ideas and findings in a variety of ways such as diagrams, physical representations and simple reports (ACSIS071) • communicating with other students carrying out similar investigations to share experiences and improve investigation skills • using simple explanations and arguments, reports or graphical representations to communicate ideas to other students	2, 3, 4, 7

Overview



Overview



Preparation for all activities

Choose the bush site

Identify a suitable bush area that contains the following species of native trees: eucalypts (e g jarrah, karri, marri or tuart), hakea, banksia, grass tree, zamia palm — see **Appendix B: Bush library**. If possible, choose two areas that differ in tree types. Invertebrates captured in each area should reflect differences in vegetation and provide interest when analysing results.

Obtain permission

Note: These steps are not required if the program is carried out in school grounds.

Lodge the application form (Licence to Take Fauna for Education or Public Purposes) with the Department of Parks and Wildlife (DPaW). A partially-completed copy of this form is available in digital-resources/forms, or download it from www.dpaw.wa.gov.au. From the main menu select Plants & animals / Licences and permits, then follow links to Fauna licensing, Fauna, Licence to Take Fauna for Education or Public Purposes. Note that 20 days needs to be allowed for processing the application. Address queries to: wildlifelicensing@dpaw.wa.gov.au.

Contact your local Council (or Authority in charge of the area) and advise them of the activity to take place. Permission needs to be sought when carrying out activities on public land.

Trapping

Collect glass jars (one per student) for pitfall traps. These must have a lid. The opening of the jar should be 100 mm in diameter and the jar should be 100 mm in height. Suitable glass jars are available from IKEA (see picture on page 26) or from info@honeypossum.com.au. It is important for traps to be uniform throughout the trapping site.

Check school requirements for taking students into the bush. One adult for each group of six students is advisable for helping to install pitfall traps. Check for students' allergies.

Provide small spades for digging holes, one for every 4–6 students.

Recording

Notebooks are an important aspect of doing science. They record original data obtained by a scientist that are the basis for analysis and prediction. Prepare one per student, as outlined in **Part 2: Exploring plants**. Pictures of tree types to be counted in the bush site are inserted (one type per page). Pages for recording birds and trapped invertebrates are included. Other records that may be suggested by students (eg weather conditions on day of recording) can be added.

Have cameras/iPads to record evidence while at the bush site.

In classroom

Set aside a wall space and narrow area immediately below it for development of the ecogram.

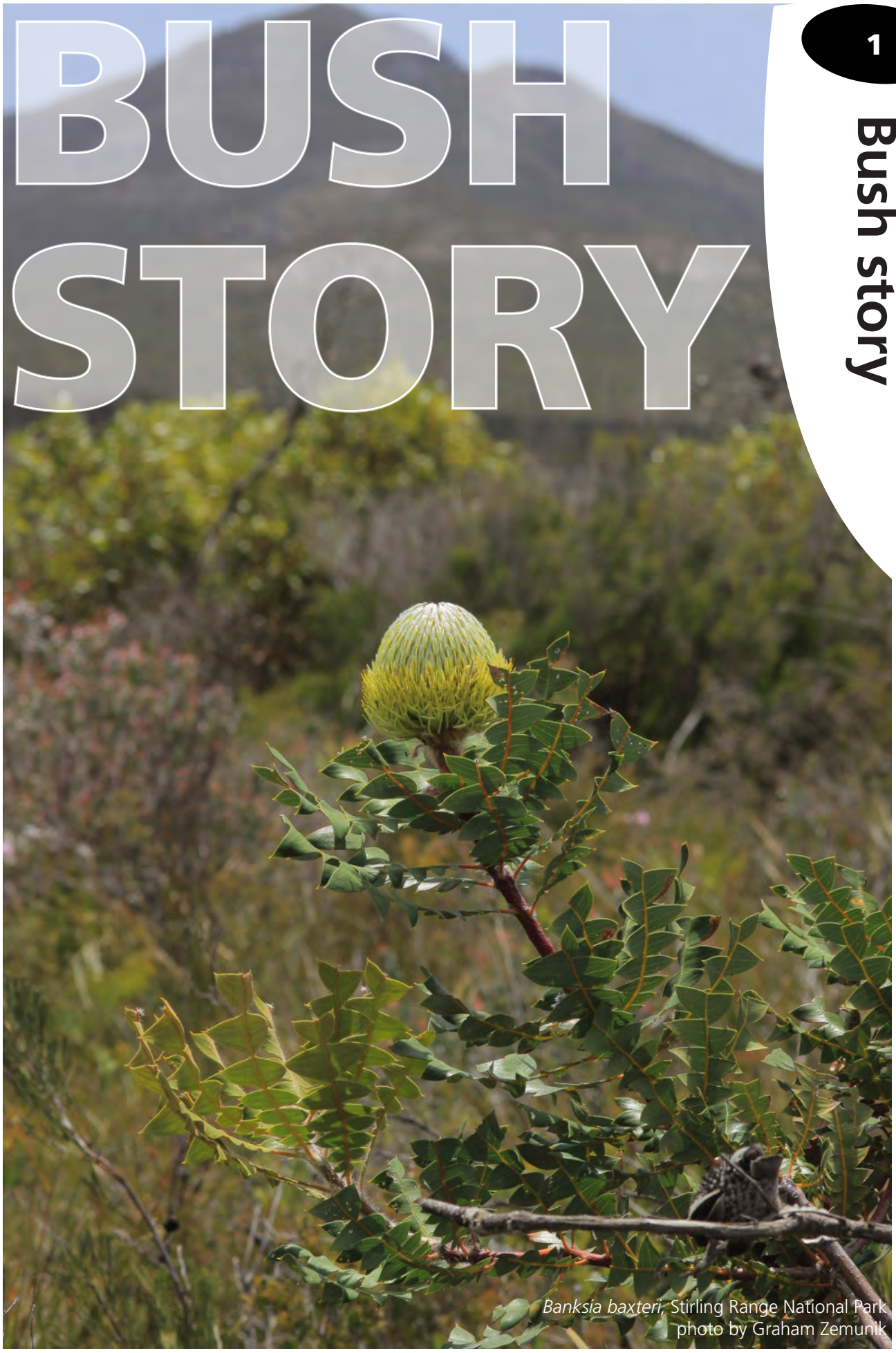
Reserve space for a word wall to record new words in bush science.

Reserve space for a 'chat-board'.

BUSH STORY

1

Bush story



Banksia baxteri, Stirling Range National Park
photo by Graham Zemunik

Purpose

This resource is intended to **Engage** students' interest in the bush, by learning about an unusual Western Australian marsupial: the honey possum.

Outcomes

Students understand that:

- honey possums are marsupials;
- honey possums live in special places; and
- honey possums depend on their environment to survive.

Materials needed

NAME	DESCRIPTION	LOCATION
Introducing honey possums presentation	This presentation contains information and pictures relating to honey possums.	digital-resources/presentations
Honey possum feeding video	Two videos show a honey possum feeding on bottlebrush and jug flower.	digital-resources/videos
A Tale of Two Honey Possums	book written by Felicity Bradshaw; illustrated by Patricia Negus. Published Perth, WA, 2008.	available from honeypossum.com.au
models to represent honey possums	• place 1½ teaspoons of sugar in cling wrap to represent weight of a male (mark with an 'M') — tie package firmly; • place 2 teaspoons of sugar in cling wrap to represent weight of a female (mark with an 'F'); and • grains of rice to distribute to each child to represent size of a baby honey possum at birth.	

Activity summary

ACTIVITY		POSSIBLE STRATEGY	SUGGESTED TIME
1.1	Teacher reads book, *A Tale of Two Honey Possums*.	teacher to class	30 min
1.2	Teacher determines students' prior knowledge of honey possums.	class discussion	5 min
1.3	Revise story, using Question/Answer sheet (p 15).	class discussion	15 min
1.4	Teacher shows presentation, *Introducing honey possums*, and video, *Honey possum feeding on bottlebrush.* Extend students' knowledge of honey possums. Identify unfamiliar words. Students ask questions about honey possums.	word wall chat board	30 min
1.5	Students draw honey possum. Drawings will be used later to construct ecogram.	individual activity	30 min
1.6	Make a class book of drawings and information about honey possums.	class working together	optional
1.7	Re-visit honey possums with dramatisation.	cut outs, finger puppets …	optional

Background information for teachers

The tiny marsupial honey possum is an unusual animal that lives in south-west Western Australia. It is known by Noongar Aboriginal people as nyuarilpiranqar[1] or 'the one who squeezes tight into blossoms'. It was later given the scientific name *Tarsipes rostratus* when it was presented to the world in 1842 by Frenchman Paul Gervais[2].

The honey possum is the only non-flying mammal that is totally dependent on flower products: pollen and nectar. For more than 60 million years, the SW corner of Western Australia has been rich in nectar-producing species such as eucalypts and banksias. This has ensured a year-round source of food that enabled honey possums to evolve over possibly 30 to 40 million years. It is a single species in its own family, an indication of its extreme specialisation and lack of close relationship to other marsupials.

Figure 1.1 Honey possum in torpor
photo by Don Bradshaw

Research on the honey possum has revealed much information about its natural history and special features (see www.honeypossum.com.au for a review). Research in the School of Animal Biology at The University of Western Australia has focussed on its reproductive physiology and energy requirements. For example a 9 g honey possum requires 7 mL of nectar and 1 g of pollen, daily, to maintain its body mass[3]. Sources of its food, nectar-rich eucalypt and banksia species, are major subjects of research in the School of Plant Science and the Kwongan Foundation, also within The University of Western Australia.

The honey possum faces major threats, such as land-clearing, plant disease, feral cats and deliberately-lit fires. It is still found in banksia territory and even in remnant patches within farming land, but its main refuges are large tracts of native bush found in National Parks and uncleared areas.

References

1) Stephen Hopper (2014), personal communication
2) Gervais, M. P., and Verreaux, J. (1842). A communication to the Meeting describing a new genus of marsupial animals. *Proceedings of the Zoological Society of London, 58*, 1-5
3) Bradshaw S. D. and Bradshaw F. D. (1999). Field energetics and the estimation of pollen and nectar intake in the marsupial honey possum, *Tarsipes rostratus*, in heathland habitats in South-Western Australia. *J. Comp. Physiol, B169*, 569-580.

Figure 1.2 *Banksia grandis*
photo by Felicity Bradshaw

Figure 1.3 *Banksia spinulosa*
photo by Chris Bryant

Figure 1.4 honey possum in *Kunzea recurva*
photo by Don Bradshaw

Activity guide

Activity 1.1 Book reading

Read *A Tale of Two Honey Possums.*

Show DVD that accompanies book which features live footage of a honey possum in its natural environment.

Activity 1.2 Introduction to honey possum

Determine students' prior knowledge by finding out who has heard of a honey possum, how big or small students think the animal might be, and what it might look like.

Distribute sugar models to emphasise low body weight of honey possums. Distribute grain of rice to each child to show weight of honey possum at birth. It is believed to be the smallest mammal in the world, at birth.

Show video, *Honey possum feeding on bottlebrush*, and draw attention to any differences between students' imagined and actual appearance of honey possum.

Activity 1.3 Story revision

Ask questions about information in the story using the Question and Answer sheet (opposite).

Activity 1.4 Learning about honey possums

Show PowerPoint presentation, *Introducing honey possums*, and video, *Honey possum feeding on bottlebrush*, for further information on honey possums.

This can be used for interaction with students by asking them questions such as: Where they might find a honey possum? What do they think it may eat? How could it eat pollen? What might hurt a honey possum?

Place new words and facts on a word wall, such as: bush, possum, joey, fur, whiskers, banksia, pouch, Spring, nectar, pollen, falcon, tiger snake, stamen, buttercup, owl, wattle bird, lizard, spider, flower, seed, shelter, refuge, burrow, reeds, torpor, drumsticks, tree, leaf, robin, woodland, eucalyptus.

Prompt students to ask questions and attach to chat board, followed by answers.

Ideas for questions could be organised along general fields of animal biology as follows:

General features

What type of animal is a honey possum? What type of mammal is it? Why is it called a marsupial? What is the pouch for? Is there milk in the pouch? Why doesn't the father have a pouch? How many other marsupial mammals do you know?

Territory

Where do marsupials live? Where do honey possums live? Why do they live there?

Diet

What do marsupials eat? What do honey possums eat? How does it eat? When does it find its food? What happens if it can't find enough to eat? What other animals sleep when there is not enough food?

Ecology (or life in the bush)

What other animals eat the same food (competition)? What animals eat honey possums (predation)? Do they live alone (solitary), or with a lot of other honey possums (social)? How long do honey possums live (life-span)? How many babies does a female have each year (reproductive strategy)?

Activity 1.5 Draw a honey possum.

Using the story or PowerPoint presentation as a guide, students draw a honey possum. Drawings may be used later for the ecogram (Activity 2.7).

Activity 1.6 Make a class book (optional)

Each student contributes a page with a drawing of a honey possum (completed in Session 1), and a short paragraph on what they found to be interesting about the honey possum. Collate and display.

Activity 1.7 Re-visiting honey possums

There are several ways of re-visiting the world of honey possums.

Students can draw animals from the story, cut them out and attach to paddle pop sticks. Allow students to retell story using these as props, along with any other materials they wish to use to represent the bush. Alternatively use appropriate hand or finger puppets to retell the story, or dramatise the story with students.

Questions about the story

PAGE	QUESTION/ACTIVITY	ANSWER
1	What are animals that have a pouch called? What are animals called if they have fur?	marsupials mammals
2	Mother possum runs around during the night. What is the name for animals that are awake during the night? Where does mother possum sleep during the day?	nocturnal in banksia leaves or under a bush
8	What is an 'enemy'? Who are mother possum's enemies?	 hawk, owl, snake, cat
9	Where was tiger snake sleeping? What else do tiger snakes eat?	base of the grass tree motorbike frogs
10	Are bush rats marsupials?	No, they do not have a pouch.
13	How do honey possums eat their food?	They use a very long tongue with bristles at its tip. Over millions of years eating nectar and pollen, honey possums have lost their chewing teeth. This means they can't eat insects, unlike birds and lizards.
14	What is another name for a eucalyptus tree? What else feeds on flowers?	gum, jarrah, marri red wattle bird
16	List some ways animals catch their food?	run and catch it; spin a web; lie in wait; sting and paralyse; make a hole in the ground with a trap-door left open …
20	'Torpor' is a special word for a form of sleeping. When honey possums cannot find enough food they curl up and sleep. Remind students that they do not eat when they are asleep.	
21	What is a 'disaster'?	something very bad that happens
23	Who stayed behind when the fire came? What sheltered them from the fire?	Mygala and tiger snake They were in the deepest part of their hole or burrow.
24	What does 'refuge' mean?	A place that keeps an animal safe, such as a clump of reeds for honey possums or underground for a bobtail lizard. This is how animals survive bush-fire in Australia.
27	What animals have whiskers? What are whiskers used for?	cat, dog, mouse, honey possum No research has been done on whiskers of honey possums; they may help to sense nearby food.
31	What does 'catastrophe' mean?	Catastrophe is another word for disaster.
32	What do female honey possums do when they are expecting their baby to be born?	They clean their pouch.

EXPLORING PLANTS

flower spikes on *Xanthorrhoea*
photo by Paul Ricketts

Purpose

This resource is intended to encourage students to **Explore** the bush by investigating plants, animals and their interdependence. Students analyse data and construct an installation (ecogram) that represents an area of bush.

Outcomes

Students:

- systematically make observations and record data;
- summarise data, including dealing with variation between observers; and
- discover that different bush areas may have differing numbers of plants; and
- understand that scientists study the bush to understand how plants and animals are connected.

Materials needed

NAME	DESCRIPTION	LOCATION
Introducing plants presentation	This presentation may be used by teachers to introduce activities in this part.	digital-resources/presentations
My bush notebook template	Students fold this template to form a notebook in which they record their observations. An alternative notebook is included that requires cutting and stapling or binding.	See **Appendix A** for instructions. digital-resources/templates
Bush library library	This library contains images of common trees and birds found in the bush.	**Appendix B** digital-resources/library
Bush trees template	This template contains pictures of trees for students to cut out and stick in their bush notebook.	See **Appendix A** for instructions. digital-resources/templates
These are useful books for the classroom: Base, Graeme (2006). *Uno's Garden*. Melbourne: Penguin Australia/Picture Puffin. Nevill, Simon (2005). *Guide to the wildlife of the Perth region.* Perth: Simon Nevill Publications. Parker, Danny (2012). *Tree*. Sydney: Hardie Grant Publishing/Little Hare Books. Tonkin, Rachel (2010). *Leaf litter*. Melbourne: HarperCollinsAustralia. Walley, Alton (2013). *Chunyar and the Cheeky Parrot*. Perth: Botanic Gardens and Parks Authority.		

Activity summary

ACTIVITY		POSSIBLE STRATEGY	SUGGESTED TIME
2.1	Discuss with students, 'What does a scientist do?' and 'What is bush science?', using presentation, *Introducing plants.* Demonstrate how to make *My bush notebook.* Add images from *Bush trees* to notebook pages.	class discussion	20 min
2.2	Students count plants in two contrasting bush areas.	field work	60 min
2.3	Identify and summarise tree count data.	group activity in classroom	30 – 60 min
2.4	Interpret tree counts — analyse and compare abundance data.	construct simple column graphs	30 min
2.5	Students research trees.	individual reading	optional
2.6	Students draw trees.	art activity	optional
2.7	Start ecogram.	whole class activity	30 min

Background information for teachers

Western Australia has an extraordinarily rich and unique plant life, particularly in the southwest. In this region, about 7380 different species of plant have been described[1] but it is likely there are more. This is not surprising considering that rocks underlying the southwest are more than 3 billion years old and surface layers have not been disturbed for hundreds of millions of years.

Figure 2.1 *Kingia australis* photo by Felicity Bradshaw, UWA

Such a long period of stability has provided the region with some of the oldest plants. Consider, for example, the grass tree *Kingia australis* which is a member of family Dasypogonaceae. It, and other species within the order Dasypogonales, have remained unchanged for 120 million years. These ancient plants have been 'sheltered' in this region since their evolution, likening the southwest to 'an evolutionary ark' (Kingsley Dixon, pers. comm.).

Figure 2.3: cluster roots photo: Hans Lambers, UWA

Age has had consequences for soil, however, as constant weathering through the eons has leached it of nutrients. As a result, plants in the southwest grow on soils that are amongst the poorest in the world [2,3].

Adapting to low levels of nitrogen and phosphorus has resulted in some interesting strategies. Carnivory is one, in which leaves are modified to capture and digest small invertebrates (for example, the Albany pitcher plant and sundews). Ninety percent of the world's sundew species are found in Western Australia. Some plants have long-lived leaves that mobilise phosphorus and send it back into the stem for redistribution when they die on the plant[4]. Some load their seeds with phosphorus at the expense of other tissues so seedlings may survive in phosphorus-deprived soil[5].

Specialised root systems are present in many genera, especially banksias. Some are in a symbiotic relationship with filaments of fungi (or mycorrhizae), in which chemicals exchanged are of mutual benefit. Other species have specialised proteoid (cluster) roots[6] that have chemical pathways to selectively 'harvest' phosphorus from soil. An alarming feature of this close relationship is the discovery of the delicate balance between plant and soil. Even a slight increase in soil phosphorus concentration is enough to severely disturb the growth of certain banksias. Soil fertilisers can result in the death of plants[7].

Figure 2.2 'Dinner-plate' sundew and Albany pitcher plant photos by Kingsley Dixon, Botanic Gardens and Parks Authority

The major threat to plants in the southwest, however, is the extent of clearing for agriculture. An international survey of the world's habitats has named this region a biodiversity hotspot[8] and the only one in Australia where species are threatened with extinction by habitat loss. Understanding plants, and the role they play in our ancient landscape, is one way of ensuring those that are left may endure.

Figure 2.4 satellite view of clearing in south-west Western Australia credit Peter Lane

References

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2) Hopper, S. (2009). OCBIL theory: towards an integrated understanding of the evolution, ecology and conservation of biodiversity on old, climatically-buffered, infertile landscapes. *Plant and Soil, 322*, 49-86.
3) Hopper, S., Harvey, M., Chappill, J., Main, A. & Main, B. (1996). The Western Australian Biota as Gondwanan heritage - a review. In: Hopper, S., Harvey, M. & George, A. (Eds.), *Gondwanan Heritage: Past, Present and Future of the Western Australian Biota*, 1-46. Sydney: Surrey Beatty & Sons Pty. Ltd.
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6) Shane, M. & Lambers, H. (2005). Cluster roots: A curiosity in context. *Plant and Soil, 274*, 101-125.
7) Hawkins, H.-J., et al. (2008). Phosphorus toxicity in the Proteaceae: A problem in post-agricultural lands. *Scientia Horticulturae, 117*, 357-365
8) Myers, N., Mittermeier, R., Mittermeir, C., da Fonseca, G. & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature, 403*, 853-858.

Activity guide

Preparation

Select bush study sites

Choose two bush areas that differ from each other. Differences may be in type of tree (for example, banksias in one and eucalypts in another); or an open space contrasted with one covered with bushes. Any difference in vegetation between the two sites will be satisfactory and will be reflected in the types of invertebrates found.

Teachers should be aware that conditions for Licence 15 (to collect animals for educational purposes) require the return of all matter removed from the bush to the collection site.

Activity 2.1 How do we do science?

in the classroom

Discuss with students: How do we do science? Activities pictured in the first part of the presentation, *Introducing plants*, include:

- We count and measure.
- We record answers in a notebook (data).
- We look for patterns in data (analysis).
- We use these patterns to predict what might happen in the future.
- We tell others about our findings (communicating).

Important safety note

Discuss with students that there are rules they must obey when they explore the bush as scientists.

- Wear suitable clothing — long pants or leggings, covered shoes and hat.
- Respect the bush:
  - do not pick flowers;
  - do not disturb animals, apart from those you have permission to trap;
  - stay on tracks where possible;
  - look where you walk; and
  - return collections to the bush.
- Depending on the bush location take appropriate precautions against snakes, spiders etc.

Continue with presentation, *Introducing plants*. Discuss with students: What is bush science?

- Exploring plants and animals in the bush.
- Explaining how they live.
- Working out how plants and animals are connected.
- Predicting what might happen if something changes.
- Telling others what we discover.

Continue with presentation, *Introducing plants.* Discuss idea that there are different plants in the bush, and that different animals may live on these plants.

Explain that students are going to count trees in two different areas of bush. They will be counting up to 4 different types of tree in each area.

How will we know what sort of tree it is? — Show *Bush library* with pictures of leaves, flowers, nuts and bark.

How will we keep track of counts? — Demonstrate how to make and use *My bush notebook*.

Divide class into 2, with each group working at one of the two selected sites.

Activity 2.2 Observing and counting plants

in the bush

Students observe and record numbers of different trees (a maximum of 4 species) in their site using *My bush notebook*. Take photographs of each site, trees, leaves and any flowers seen.

Activity 2.3 Summarise plant data

in the classroom

As a class, identify different tree species found in the bush, using the document, *Bush library*, and projected images on an IWB.

Set up a master data sheet (see example in **Appendix C** of this guide) to contain students counts of each tree. Keep data separate for each area.

Discuss why students may have different tree counts for the same area. How can we choose one value to represent the class?

Calculate the middle (or median) number of trees. This middle number will be used to construct column graphs. An example may be found at http://www.mathsisfun.com/median.html.

Example:

Arrange banksia counts in ascending order:

6, 7, 9, 10, 11, 11, 13, 14, 15, 16, 17, 17

The middle in this example consists of 2 values: 11 and 13. To find the median, add them and divide by 2, which yields 12.

Set up a summary table on an IWB for children to enter calculated medians, for each tree, in each area, also shown in **Appendix C**, below.

Children may present summary data as column graphs (as in Figure 2.5). Graphing skills and knowledge of children will dictate what level of graphing to use.

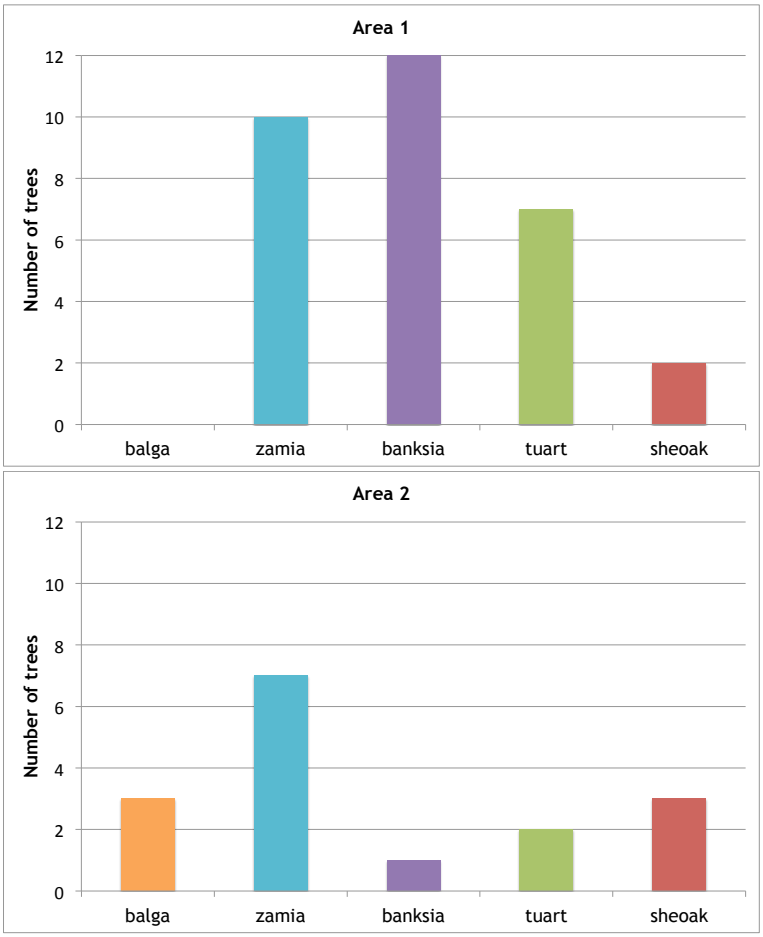


Figure 2.5 Column graph of median number of trees in two bush areas (produced in **Activity 2.3**)

Activity 2.4 Interpreting tree counts

Provide a simple interpretation of data in the column graph.

- Which group had the most trees and which group had the least?
- Which group had the largest number of one tree species, and which had the least?

Activity 2.5 Researching trees

Encourage children to select one tree species and research specific information about it, using books and the Internet. A good reference book is *Chunyar and the Cheeky Parrot* by Alton Walley, published by Botanic Gardens and Parks Authority, 2013.

Information may include:

- What is my common name, scientific name and Aboriginal name?
- What do I look like?
- How long do I live?
- How tall can I grow?
- What does my flower look like?
- What animals live in me?

Activity 2.6 Drawing trees

Using photographs and other biological books as a guide, children draw the tree they researched. Make sure they pay attention to the colour of the tree. Highlight different shades of green or brown. Look at paint colour charts to illustrate different shades of colour. Explore various art techniques to represent shiny, dull, smooth and rough surfaces in their drawings.

Activity 2.7 Starting the ecogram

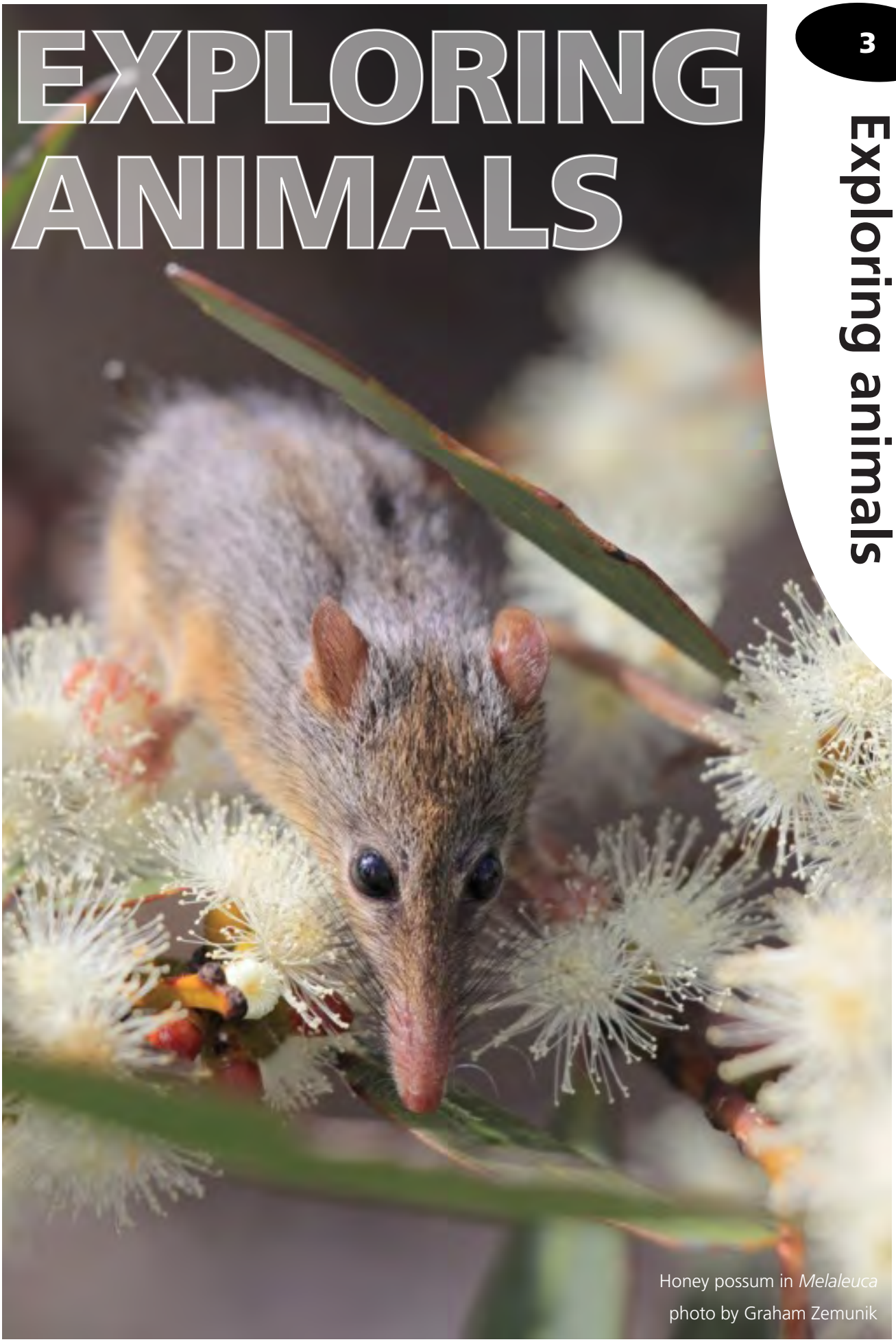
In a group, children produce large representations of trees recorded in their bush. Make sure the highest tree occupies the full height of the wall (or paper), if possible. Drawings may be done by class, teacher, specialist art teacher, interested parent or everyone working together. Label trees with their names.

Add drawings of honey possums done in **Activity 1.4** to appropriate trees.

Figure 2.6 Ecogram under construction
Paintings of trees are attached to the wall (**Activity 2.7**); leaf litter is placed on the bench beneath the paintings (**Activity 4.6**); and 'pollen grains' are stuck onto the tree paintings (**Activity 5.5**).

Figure 2.7 Adding connections to the ecogram
In **Activity 7.1** students make connections between components of the ecogram, using coloured tape.

EXPLORING ANIMALS



Honey possum in *Melaleuca*
photo by Graham Zemunik

Purpose

This resource is intended to encourage students to **Explore** the bush by investigating plants, animals and their interdependence. Students analyse data and construct an installation (ecogram) that represents an area of bush.

Outcomes

Students:

- understand that a range of invertebrates live in the bush;
- identify invertebrates using a dichotomous key; and
- understand that increased diversity of plants may be associated with increased diversity of animals.

Materials needed

NAME	DESCRIPTION	LOCATION
Introducing animals presentation	This presentation may be used by teachers to introduce activities in this part.	digital-resources/presentations
My bush notebook template	from **Part 2**	digital-resources/templates
What invertebrate is it? worksheet	This dichotomous key will help students indentify invertebrates they trap.	**Appendix D** digital-resources/worksheets
License to take fauna form	This partially completed form, 'Application for a licence to take fauna for education or public purposes', must be submitted to the Dept of Parks and Wildlife.	digital-resources/forms
Master data table	Note for teachers: Copy master data for the Department of Parks and Wildlife when sending in the returns required by the Licence to Collect.	**Appendix E** contains an example.
glass jars with lids, gummed labels, trowels, wooden probes, magnifying glasses		

Activity summary

	ACTIVITY	POSSIBLE STRATEGY	SUGGESTED TIME
3.1	Planning: discuss with students, 'What animals do you find in the bush?', using presentation, *Introducing animals.* Prepare pit traps; plan trapping site (make master plan); prepare students for bush visit (clothing ...)	class discussion	30 min
3.2	Exploring animals: students set pit traps to trap invertebrates in two contrasting bush areas, according to master plan. Students collect traps, observe other features (birds).	field work	60 min (allow extra time to get to site) 30 min
3.3	Identify and summarise data	group activity in classroom	60 – 90 min
3.4	Analyse and graph invertebrate counts.	create simple column graphs	30 – 60 min
3.5	Interpret invertebrate data.	class activity	30 min
3.6	Return invertebrates to collection sites.	class activity	15 min

Background information for teachers

Vertebrates and invertebrates

Vertebrates are animals that have backbones. The backbone (or vertebral column) consists of a series of bony vertebrae hinged together that forms a flexible rod inside the body. Apart from body support, bones are the solid attachment that muscles need to exert tension. As muscles are attached on the outside of their bony attachment, they can expand outwards as animals increase in size.

Figure 3.1 End view of vertebra (left) and four vertebrae in a column (right)
photo by Felicity Bradshaw (UWA)

Invertebrates have no vertebral column. Their hard surface for muscle attachment, called an exoskeleton, is on the outside of their body. Their muscles are, therefore, attached on the inside of the hard surface and an invertebrate is able to grow only when the animal loses its exoskeleton. The cicada in Figure 3.2 has split open the upper part of its body, or thorax, and pulled itself out of its hard outer surface, leaving the exoskeleton behind.

Figure 3.2 Cicada exo-skeleton
photo by Felicity Bradshaw (UWA)

Because they have no internal bony support invertebrates are small, unless they are aquatic. The body of a squid, which is supported by water, may reach many metres in length.

Invertebrates comprise about 96 % of the world's animals and have a wide range of body plan. Land invertebrates are divided into three major groups: worms, arthropods and molluscs.

- Worms include nematodes, which have an unsegmented body shape, and earthworms, whose body consists of rings or segments.
- Molluscs include snails.
- Arthropods, which include all invertebrates with jointed legs, are the most diverse group. It contains: arachnids (spiders, ticks, mites and scorpions, with eight legs); chilopods (centipedes, with one pair of legs on each body segment); diplopods (millipedes, with two pairs of legs per body segment); crustaceans (slaters are one of the few land crustaceans, requiring external moisture to 'breathe'); and insects.

There are more than a million species of insect in the world. All have six legs and mostly one or two pairs of wings (ants, dragon-flies, butterflies, bees, flies, wasps, beetles). Some have a hard covering on the first pair of wings (beetles, grass-hoppers).

For further information on the division of body parts, see www.diffen.com/difference/Invertebrate_vs_Vertebrate

Land invertebrates are found, and feed, on every part of plants. Caterpillars, beetles and crickets eat leaves; aphids, cicadas and snails eat stems; maggot fly larvae eat roots; weevils eat seeds; bees, wasps and butterflies eat nectar and pollen; termites eat wood; and many insects deposit their eggs in fruit, to provide food for hatchlings.

Some plants have intriguing methods for deterring damaging insects. The tea plant synthesises tannic acid, discouraging insects and micro-organisms.

The rainbow plant (*Byblis*) has sticky hairs that trap insects when they are attracted to the 'glue', believing it to be nectar.

A daisy, *Tanacetum coccineum*, makes pyrethrum which is a chemical that is poisonous to insects. Tasmania is the world's largest producer of pyrethrum for use as an insecticide.

Figure 3.3 Stem of *Byblis* plant
photo by Kingsley Dixon, Botanic Gardens and Parks Authority

Invertebrates are also prevalent in soil, especially in the top layer within the litter. Here they feed on rotting matter (both plant and animal) and enrich soil with the breakdown products in their droppings:

- dung beetles digest vertebrate faeces (dung from cows and horses);
- termites digest old wood;
- earthworms aerate soil by feeding at the base of their burrowing tube and excreting at the surface; and
- carnivores (spiders, wasps, mantids and lady-bird beetles) eat each other and pass digested products into the soil.

Figure 3.4 Dung beetle
photo by Evan. GFDL. commons.wikimedia.org/wiki/File:Dung_beetle.jpg

Pit-fall trapping

Pit-fall trapping is a common method used for capturing small terrestrial fauna (land animals). It is also used for investigating ground-dwelling invertebrates. A container with slippery sides (glass, not plastic) that is inserted into the ground with the rim at ground surface level may be used as a pit trap (Figure 3.5). It's best to insert the container with the lid on in order to keep traps free of soil. Lids are removed when trapping.

Traps should be inspected daily. This is not necessary when trapping invertebrates, but traps should be checked each two or three days to free any small lizards that have fallen in.

When freeing a lizard, hold it firmly (but gently) in the region of the forelegs (as in Figure 3.6). Do not hold a lizard by its tail as the lizard will jettison it in order to escape.

Sites for a pit-fall grid depend on identifying possible micro-habitats of common invertebrates found in the area. For example, termites or slaters may be found near rotting trees; ants and spiders are found in sandy open ground; millipedes are found in rotting leaves; grasshoppers near grass; and most types are present in litter under trees. A grid system is used (rather than long lines) in order to maximise capture rate.

Figure 3.5 Invertebrate trap (left) and invertebrate trap in ground (right)

Figure 3.6 Holding a lizard

Figure 3.7 Insect camouflaged amidst dead leaves

Activity guide

Important safety note

Remind children of precautions to be taken in the bush. Students should not handle invertebrates they catch — use wooden probe or paddle stick to observe animals while in the trap.

Activity 3.1 Introducing invertebrates

in the classroom

Discuss with students what animals they may find in their bush area, and how they might catch them. As they will be using pitfall traps, what might they find in their traps?

Discuss where ground-living invertebrates might be found, using ideas mentioned in the background information for teachers. This will guide students to select the best sites to install traps. Close inspection of each area may uncover differences that can be exploited, such as shaded/sunny, grassy/under trees, near fallen logs/open ground.

In Figure 3.9, a class of 24 students has been divided between two sites that contain different tree types (type 1 and 2). Traps were placed, in each area, along two lines at 4 to 5 metre intervals. Each pair of lines was also 4 to 5 metres apart. This provides a grid pattern that takes advantage of a particular habitat. If only one site is available, select different aspects within the site for each row, along the lines outlined above. It is important to have similar numbers of traps at each site. If there are 30 children, for example, there will be 15 traps in each site, with 7 or 8 traps in each line.

Assign each student a trap row and number (e g A3). Students use these, together with their name, to label the lid of their trap. Teachers should make a plan similar to Figure 3.9 to record positions of students' traps, for use at the trapping sites.

Figure 3.8 Studying an invertebrate
photo by Jennifer Russell

Activity 3.2 Working with pit-traps

in the bush

Plan to have one adult for each 5 – 6 children. Install traps during a rain-free week.

Demonstrate how children will install their trap. Each child digs a hole large enough to fit their jar. Place jar in hole (with lid on) ensuring rim is flush with ground, as seen in background information for teachers. Explain why it is important to have rim of jar and ground surface at the same level. When jar is in place, remove lid and take back to classroom.

Children should check traps every 2 or 3 days, if possible. If not, teacher should check them. When traps are collected (after no more than 7 days), each student first replaces lid on their trap and, pulling gently, removes it from ground. Ensure students fill in their holes, reminding them that this is part of respecting the natural state of the bush.

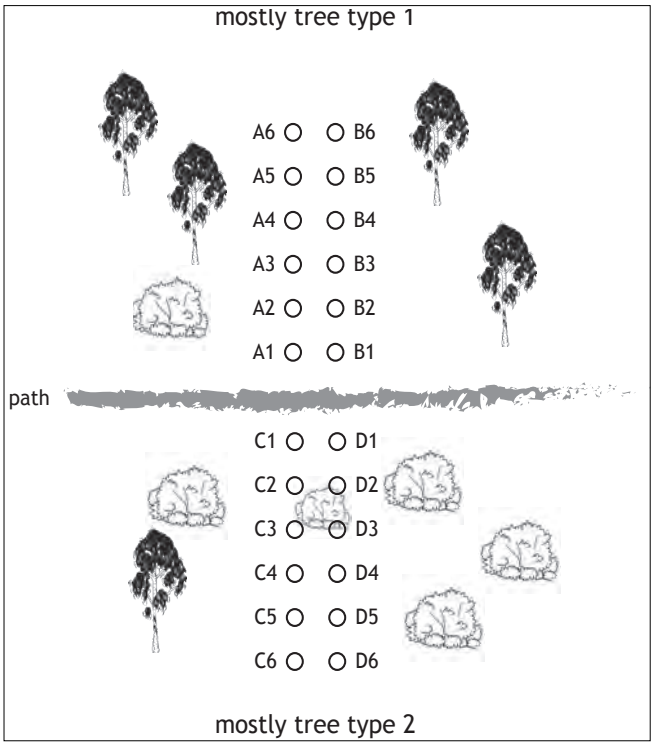


Figure 3.9 Example trap site plan

Activity 3.3 Working with invertebrates

in the classroom

Observe traps before returning them to students to ensure contents are safe. Invertebrates will be mostly benign, particularly in the metropolitan area. Scorpions, large centipedes or jumping spiders may be found in outer regions. These should be removed carefully by teachers (remember to record them in the data sheet). Students use a wooden probe or paddle stick to observe animals while in the trap.

Students identify each type using a dichotomous key, *What invertebrate is it?*, and enter tally in *My bush notebook*, in space provided.

Students examine invertebrates with a magnifying glass and describe in detail (body parts, number of legs, antennae etc).

Students draw an invertebrate on a blank page in their notebook. Highlight importance of correctly labelling parts of an invertebrate.

Draw and colour another example from their collection. Store drawings for later addition to the ecogram.

Activity 3.4 Analysing data

Entering data: Set up a master data sheet, keeping the 2 areas separate (as for recording trees). Students enter tallies for each type of invertebrate in the appropriate space (see **Appendix E**, below).

Total number of invertebrates captured in each trap-line are calculated. Use calculators if necessary. Graphing: Students construct column graphs of data for each area. This may be difficult if one invertebrate greatly outnumbers other types (as in Figure 3.10, where millipedes dominate the count). In this case teachers may choose to look at the dominant species separately and redraw graphs without them. There is an opportunity in this case to talk about an introduced (feral) species (Portuguese millipedes) and their presence in plague proportions.

Activity 3.5 Interpreting data

Questions to ask: What types of invertebrate were found? Were there any flying ones? Why not? Identify which groups were found under trees, under bushes, or in a clearing. Which group had the most invertebrates and which group had the least? Which group had the largest number of one type of invertebrate, and which had the least? Does there appear to be any relationship between the number of invertebrates and vegetation type?

Students compare column graphs for plants and animals. Help students make correlations between invertebrates and plants in each site. For example using Figures 3.8 and 3.10, discussion could include:

- Are there more trees in Area 1 than in Area 2? Are there more millipedes in Area 1 than Area 2?
- Does that mean that millipedes need trees? Why might millipedes need trees? Where there are more trees, will there be more leaves on the ground? Might millipedes be better off (advantaged) by a more dense leaf layer on the ground (litter)? What do millipedes eat? Are rotting leaves food for millipedes?
- Compare the number of slaters in the two areas. What type of invertebrate is a slater? (a crustacean that needs water to breathe and a cool environment). Have students noticed them under rotting wood? Does this explain why there are more slaters where there are more trees?

Activity 3.6 Releasing invertebrates

In the bush

Invertebrates should be returned to the bush site, whether alive or dead. Apart from being a condition of the Licence to Collect, this practice emphasises the importance of invertebrates in the bush system (elaborated later) and sets a good example for children in valuing animal life.

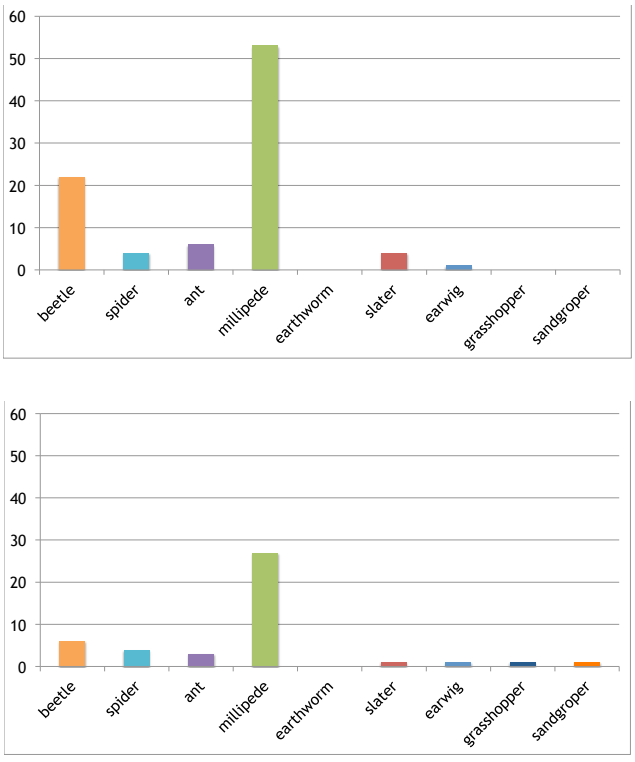


Figure 3.10 Distribution of invertebrates in two areas of bush

EXPLORING LEAVES AND LITTER

4

Exploring leaves and litter

Leaf litter
photo: Don Bradshaw

Purpose

This resource is intended to encourage students to **Explore** the bush by investigating plants, animals and their interdependence. Students analyse data and construct an installation (ecogram) that represents an area of bush.

Outcomes

Students understand that:

- bush litter (leaf litter) is different from rubbish (bad litter);
- bush litter comprises what falls from trees; and
- bush litter is an important habitat for invertebrates.

Materials needed

NAME	DESCRIPTION	LOCATION
Introducing leaves and litter presentation	This presentation may be used by teachers to introduce activities in this part.	digital-resources/presentations
Bush library fact sheet	This fact sheet contains images of common trees and birds found in the bush.	**Appendix A** digital-resources/library
Leaf worksheet	This table may be used by students to record observations about leaves.	**Appendix F**
30 cm x 20 cm zip-lock plastic bag for collecting objects off the ground, one per student, labelled with student's name		
magnifying glasses		
reference book: *Leaf litter* by Rachel Tonkin, Harper Collins (2010).	This book contains a series of lift-up flaps revealing many creatures that live in litter.	

Activity summary

ACTIVITY		POSSIBLE STRATEGY	SUGGESTED TIME
4.1	Planning Discuss with students, 'What is litter?', using presentation, *Introducing leaves and litter.*	class discussion	20 min
4.2	Collecting litter Students collect leaf litter and sample leaves from trees.	field work	30 min
4.3	Classifying litter	group activity in classroom	30 – 60 min
4.4	Working with leaves	individual maths activity	30 min (optional)
4.5	Drawing birds	individual art activity	60 min (optional)
4.6	Adding to the ecogram	class activity	30 min (optional)

Background information for teachers

Litter is a word used to describe what lies on the ground under trees. However litter is much more than dead parts of trees, and its importance should not be underestimated.

Litter:

- provides food and shelter for invertebrates, smaller animals (called micro-organisms) and fungi, all of which in turn provide food for plants;
- protects soil from drying out, which keeps moisture (necessary for invertebrates and micro-organisms to survive) on the surface;
- provides a similar protection for seeds; and
- prevents soil containing food for plants from being blown away by wind.

Without litter, most plants would not survive.

Figure 4.1 Leaf litter

For more information see *Leaf Litter* by Rachel Tonkin (HarperCollins Australia Publishers). This book contains a series of lift-up flaps exposing many creatures that live in litter.

A useful link for understanding the role of micro-organisms and fungi in soil is found at wikipedia.org/wiki/Plant_litter. The function of these as providing food for plants is presented in **Part 6: Food**.

Activity guide

Activity 4.1 What is litter?

in the classroom

Discuss with students the nature of litter.

What is it? Litter is the word for what lies on the ground.

Make clear the distinction between litter in the bush and litter that is rubbish. Students discuss differences between 'good' and 'bad' litter. A discussion on this topic could introduce a collection of rubbish litter from their bush site.

What might they find in it? In the bush, it comprises what falls from trees, such as leaves, stems, bark, branches, flower petals, seeds and seed cases such as gumnuts, banksia nuts and sheoak cones.

Add words to the Word Wall.

Discuss the function of litter with students.

> It provides food and shelter for invertebrates, micro-organisms and fungi. Litter protects soil from drying out. It keeps moisture at the surface, which invertebrates, micro-organisms and seeds need for survival. Most importantly, litter prevents soil containing food for plants from being blown away by the wind. Without litter, most plants would not survive.

Figure 4.2 Leaves of different shapes and sizes

Activity 4.2 Collecting litter

in the bush

Students take their copy of *My bush notebook* and a snap-lock plastic bag to the bush area. Collect samples of litter, ensuring that collections contain litter from under trees that they recorded earlier. Collect leaves of different colours, textures or shape, along with any pods, nuts or seeds. Flowers that have fallen to the ground, interesting bark and feathers may also be collected.

Each child also collects a sample leaf from trees recorded earlier. These will be compared with dead leaves.

Look and listen for birds in the area. Record them in *My bush notebook*.

Students look for signs of animals, such as tracks, diggings or scats (scientific name for animal poo). Photograph any animals, or signs of animals, that you find. *Tracks, Scats and Other Traces* by B. Triggs, Oxford University Press (1996) is a useful reference.

Depending on the ability of the children, an iPad app such as MadPad HD may be used to record sounds from the bush. This may include birds singing, insects chirping, wind blowing in trees or branches rubbing against each other. This may be used later in class to make music.

Figure 4.3 Collecting leaf litter
photo by Jennifer Russell

Activity 4.3 Classifying litter

in the classroom

Each student empties their snap-lock bag onto newspaper and classifies materials they found. For example, they may group items into leaves, bark, seeds and feathers. Each group describes their classification.

Students identify bark, seed pods, nuts and cones (refer to **Appendix B: Bush library**) and set aside for addition to the ecogram.

Using sample leaves collected from each tree, students classify their litter leaves and sort into different tree types.

Activity 4.4 Working with leaves

Distribute copies of **Appendix F: Leaf worksheet** (at the end of this guide) to each student.

Students examine green sample leaves collected from the bush and enter characteristics and dimensions into their worksheet. Students calculate surface area of each leaf.

Discuss:

- Why are some leaves leathery? A 'leathery' surface protects leaves from drying out when there is no rain; some areas in Australia have no rain for years.
- Why are the edges of some leaves prickly with a tip that often ends in a spine? It protects leaves from being eaten.
- Why are leaves green? They contain chlorophyll; add to Word Wall.
- What do leaves do? Chlorophyll in leaves uses sunlight to make food for plants.
- Do wide leaves make more food than narrow leaves? Students select a narrow leaf (eg grass tree) from their table to compare with a wide leaf (gum-tree) and find an answer. Place this exercise on Chat Board.

Draw a leaf. Each student selects a leaf to draw in detail. Observe with magnifying glass or use light table. Look closely at veins in leaves. Why do leaves have veins? They are a transport system that connects leaves to stems and roots.

Activity 4.5 Drawing birds

Birds seen and recorded in *My bush notebook* are identified from the Bush library. A selection of birds such as kookaburra, magpie, honeyeater and red wattle bird may be drawn and coloured by students, for later addition to the ecogram.

Activity 4.6 Adding to the ecogram

- Place leaf litter on the ground, under appropriate trees, in the ecogram.
- Place seeds or seedpods, under appropriate trees, in the ecogram. Alternatively, tape to a branch of an appropriate tree in the ecogram.
- Add invertebrates that were drawn previously, placing these in or on litter.
- Place birds on or between trees, depending on where they were seen.

FLOWERS

Gum tree blossum, York
photo by Chris Bryant (ANU)

Purpose

This resource introduces students to the life cycle of plants through a study of banksia flowers. They learn about the diversity and importance of pollinators.

Outcomes

Students understand that:

- flowers have different parts, which they name;
- flowers require a pollinator to produce seeds; and
- seeds are a part of the life-cycle of plants.

Materials needed

NAME	DESCRIPTION	LOCATION
Introducing flowers and pollination presentation	This presentation may be used by teachers to introduce this topic.	digital-resources/presentations
Pollen library library	This sheet for printing contains images of pollen from different trees.	**Appendix G** digital-resources/library
banksia flowering spikes	Three or four spikes will provide enough flowers for 20 to 30 students.	available from florists
banksia nuts		

Activity summary

ACTIVITY		POSSIBLE STRATEGY	SUGGESTED TIME
5.1	Teacher shows presentation, *Introducing flowers* (slides 1 – 8). Students draw a banksia flower and label their drawing.	class discussion	30 min
5.2	Teacher continues with presentation, *Introducing flowers* (slides 9 – 14), to introduce pollination.	class discussion	15 min
5.3	Students draw different stages of a banksia life cycle.	individual activity	10 min
5.4	Dealing with data variation – students count seeds produced by a banksia nut.	maths activity	20 min (optional)
5.5	Students act out roles as pollinators, adding pollen to approriate trees on ecogram.	class activity	20 min

Background information for teachers

Banksias are relics from the super-continent Gondwana, and have been around for more than 50 million years. They occur around the periphery of Australia, with ninety percent of species growing in the south-west corner of Western Australia.

They are heavy producers of nectar and provide an important food source for many nectarivores such as honeyeaters, small mammals (rodents, honey possums, pygmy possums, marsupial gliders and bats) as well as a host of invertebrates. Vertebrates play a significant part in pollinating banksias.

Figure 5.1 honey possum on *Banksia grandis*
photo by Stephen Hopper

Banksia 'flowers' are unusual — what is seen as a flower is actually a flower spike (or inflorescence) containing hundreds or maybe thousands of flowers. *Banksia grandis* (bull banksia) for example has around 6000 flowers on a single inflorescence. Without obvious petals or sepals, banksia flowers appear stripped to the bare essentials: pollen-bearing anthers and a female style with ovule at its base.

Comparatively few flowers on a banksia inflorescence are pollinated. These may be identified by enlarged woody follicles, each one surrounding a seed. These protrude from the spike (now called an infructescence as it is the 'fruit' of the banksia) and indicate how many flowers have been pollinated successfully.

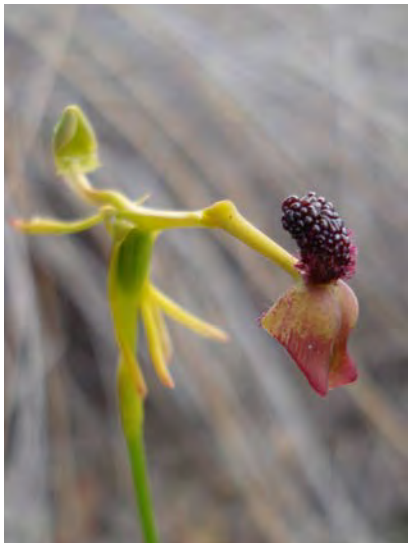
The woody infructescence (or nut) is a familiar object on a banksia tree. Open follicles indicate the number of seeds that have been liberated from the nut.

Figure 5.2 Banksia fruit or nut (infructescence
credit: Alex George

Pollination

Pollination is the fundamental process ensuring continuation of plant species, and has probably operated since flowering plants (angiosperms) evolved. Long periods of co-evolution by plant and pollinator have resulted in fascinating examples of plant/pollinator interaction[1, 4].

The case of the thynnine wasp is one such example. A flightless female wasp waits on top of a plant stem for a male to fly in, carry her off and mate in mid-flight. The hammer orchid (Drakaea) is an endangered Australian genus, whose labellum mimics the head and abdomen of the female wasp.



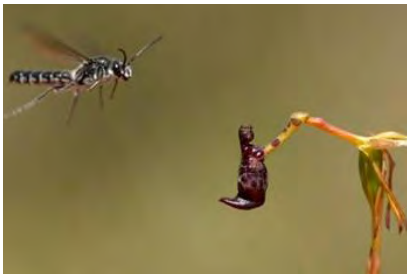


Figure 5.3a hammer orchid *Drakea* sp. (left)
photo by Ryan Phillips
Figure 5.3b wasp approaching hammer orchid (centre)
photo by Bert and Babs Wells, Department of Parks and Wildlife
Figure 5.3c wasp pollinates hammer orchid (right)
photo by Suzi Bond

A volatile chemical compound (pheromone) in the labellum also entices the wasp. The male wasp is attracted to the orchid and tries to carry off the 'female' wasp. The momentum of the wasp attempting to fly off with the labellum activates the hammer. This swings back and positions the wasp near the flower's pollen presenters. Pollen, adhering to the wasp, is then transported to another orchid, effectively pollinating it[4].

Figure 5.4 tomato flower
photo by Felicity Bradshaw

Some flowers have their anthers protected and enclosed in a tube with only a small aperture at the end from which pollen can be released, such as the flower of the tomato[3]. A casual visitor to the flower will not be rewarded with a feed of pollen. It is only when a bee lands on the flower, closes its wings and vibrates its body at a suitable frequency that the anthers liberate pollen grains through the aperture. These vibrations can be heard, leading to the term 'buzz pollinators'.

Many species in Western Australia's banksia territory are buzz-pollinated by native bees[2]. Introduced bees, such as the European honeybee, *Apis mellifera*, do not buzz-pollinate. Reduction in numbers of native buzz-pollinators is of concern for plant conservation.

Plant evolution has apparently favoured bees as pollinators. Many plants guide bees to their nectaries (nectar reservoirs) with flight paths. These pigmented areas on petals exploit bees' ultraviolet vision. The eyes of bees see light at different wavelengths than the eyes of most vertebrates. Only by examining flowers under ultraviolet light do these flight paths become apparent.
See en.wikipedia.org/wiki/Nectar_guide

Figure 5.5 pea flower
photo by Don Bradshaw

Pea flowers also have concealed nectaries and stamens that appear to protect their food supply from visitors. This would seem to be at odds with a need for pollination. Pea flowers, however, attract a large variety of bees, many of which are pea specialists. Bees are heavy enough to spring open the protective cover of petals when they land on the flower[2].

References

1) **Bradshaw, S. D., (2014). Pollination Vectors: Vertebrates. In: Lambers H., (Ed.),** *Plant Life on the Sandplains in Southwest Australia, a Global Biodiversity Hotspot* **(Chapter 7). Perth, Western Australia: UWA Publishing.**

2) **Houston, T. (2014). Pollination Vectors: Invertebrates. In: Lambers, H., (Ed.),** *Plant Life on the Sandplains in Southwest Australia, a Global Biodiversity Hotspot* **(Chapter 7). Perth, Western Australia: UWA Publishing.**

3) **Houston, T. F., & Ladd, P. (2002). Buzz pollination in the Epacridaceae.** *Australian Journal of Botany. 50*, **83-91.**

4) **Phillips, R. D., Peakall, R., Hutchinson, M. F., Linde, C. C., Xu, T., & Dixon, K. W. (2014). Specialized ecological interactions and plant species rarity: The role of pollinators and mycorrhizal fungi across multiple spatial scales.** *Biological Conservation, 169*, **285-295.**

Activity guide

Activity 5.1 Understanding flowers

Students draw parts of a common flower and label accordingly. These should include: petals (no need for sepals); stamens (male part of the flower) supporting anthers that produce pollen; style (female part of the flower) with a sticky tip called stigma; and ovule at the base of the style. Add these words to the word wall.

Provide students with banksia flowering spikes and explain how the flowers differ from others by having no obvious petals. Demonstrate how to pull each flower from the flowering spike, using plastic forceps. Students may need help with this. Use magnifying glasses to identify the simple parts of each flower as shown in the presentation, *Introducing flowers and pollination*. A microscope attached to computer/whiteboard may be used to highlight detailed sections of a flower.

Students draw a banksia flower and label their drawing.

Activity 5.2 Understanding pollination

Discuss tactics used by flowers to ensure that their pollen is transported to another flower (e g coloured petals to attract insects; flight path as a guide to the nectar-producing area (nectary) for bees; or sugary nectar as a food reward). Ask students where they may have noticed a bee, ant or butterfly on a flower. Did they know that it was drinking nectar?

Discuss who, or what, transports pollen and how it is carried (bees have a pollen basket on their back pair of legs; honeyeaters carry pollen on their forehead; and honey possums carry pollen on their long snout).

Using presentation, *Introducing flowers and pollination*, step through pollination and seed production in a banksia flower. Outline the passage of pollen as contents grow down the style (actually burrow through it) and join with the contents of the ovule at the base of the flower.

Figure 5.6 Bee with pollen basket
photo by Don Bradshaw (UWA)

Activity 5.3 Life cycle of a banksia

Students draw stages in the banksia life-cycle: bud; flower spike; woody fruit (nut); seed; tree (as shown in presentation, *Introducing flowers and pollination*).

Activity 5.4 Dealing with data variation

Scientists are faced with variation when recording data for living objects. They record results as an average (or mean) within a defined range. This activity provides a simple exercise that demonstrates the concept of a middle value.

Students count and record the number of open follicles in a banksia nut. This exercise identifies how many seeds have been released from the nut. There will be variation as some students count more accurately than others. What is the actual number? Find the middle number (or median) as set out in **Activity 2.3**.

Activity 5.5 Role play

Assign each student a role as a pollinator. This will depend on the number in the class and the number of trees represented in the ecogram. For example, if four trees are represented, four pollinator types are needed. The class is therefore divided into four groups with one quarter assigned as honey possums, one quarter assigned as honeyeaters, one quarter assigned as red wattle birds and one quarter as bees.

Using the pollen library (in digital-resources) each student cuts out several pollen grains, sticks them to a cottonwool ball, and attaches them to the appropriate tree (eg banksia pollen to the banksia tree, and so on).

Figure 5.7 New Holland honeyeater on bottlebrush

photo by John Milbank

FOOD

jewel beetle
photo by Felicity Bradshaw

Purpose

This resource introduces students to how living organisms obtain energy for life processes.

Outcomes

Students understand that:

- plants use energy in sunlight to produce sugars from carbon dioxide, water and minerals through photosynthesis;
- sugars produced by plants contain energy; and
- animals use this energy by consuming plants or other animals.

Materials needed

NAME	DESCRIPTION	LOCATION
Introducing food presentation	This presentation may be used by teachers to introduce the concepts of producers and consumers, and how living things may be classified by their type of food.	digital-resources/presentations
Honey possum feeding on honey solution video	This short video shows a honey possum feeding on a honey solution at the Centre for Native Animal Research (University of Western Australia).	digital-resources/video

Activity summary

ACTIVITY		POSSIBLE STRATEGY	SUGGESTED TIME
6.1	**Understanding food production** Teacher shows presentation, *Introducing food* (slides 1 – 7). Students discuss processes by which plants produce 'food' in the form of sugars.	class discussion	10 min
6.2	**Understanding food consumption** Teacher continues with presentation, *Introducing food* (slides 8 – 10). Show videos, *Honey possum feeding on honey solution* and *Honey possum feeding on jug flower*. Students discuss processes by which animals get energy from food.	class discussion	10 min
6.3	**Classifying food consumption** Teacher completes presentation, *Introducing food* (slides 11 – 16). Students consider their own role as consumers.	class discussion	10 min
6.4	**Identifying eaters and what they eat in their bush** Students research types of food eaten by organisms in their ecogram. They draw T-diagrams that correlate eaters with what they eat in the bush. These will be used in Part 7.	individual activity	30 min

Background information for teachers

Why organisms need food

Living organisms, including plants and animals, continuously use energy to grow, reproduce and repair. This energy comes from chemical breakdown of food in a process known as **cellular respiration**. All plants and animals respire as they all need and use energy. A simple equation for respiration is:

food + oxygen → energy + carbon dioxide + water

The question is: where do organisms get their food?

Plants are **autotrophs**. They make or synthesise their own food through the process of photosynthesis. Another name for an autotroph is **producer**.

Animals, on the other hand, are **heterotrophs**. They must consume other organisms as they are unable to synthesise their own food. Another name for a heterotroph is **consumer**.

Photosynthesis

Photosynthesis is an incredibly important process. It is also very complex!

Put simply, plants (also algae and some bacteria) use energy in sunlight to convert simple molecules (carbon dioxide and water) into complex organic molecules (sugars) that store energy. Conversion of carbon dioxide into organic molecules is known as **carbon fixation**. Oxygen is also produced in this process.

light energy + carbon dioxide + water ⇀↽
sugars + oxygen

Plants use special structures, known as chloroplasts, to photosynthesise. Chloroplasts contain chlorophyll pigments that receive light energy. Chlorophyll absorbs light mainly in the violet and blue wavelengths. Green light, which isn't absorbed, is reflected which is why most plants appear green.

Carbon dioxide gas enters plants through stomata, which are tiny openings in leaves and stems. Oxygen gas leaves plants by the same means. These specialized cells open or close in response to signals such as turgor pressure (amount of water in plant cells), light and temperature.

Water enters plants via root systems. Roots also anchor plants and sometimes act as storage.

Plants have transport or vascular systems. Xylem transports water and minerals while phloem transports food throughout the plant.

Food consumption

Animals are consumers as they are unable to make their own food. Herbivores, or plant-eating animals, are often known as **primary consumers**. They have specialized mouthparts and digestive systems that can digest plant material. Koalas and kangaroos are herbivores.

Carnivores, or animal eaters, may be secondary or tertiary consumers. Carnivores that eat herbivores are called **secondary consumers**. Carnivores that eat other carnivores are called **tertiary consumers**. For example, kookaburras and tiger snakes are secondary consumers. Western quolls (chuditch) are tertiary consumers as they eat lizards, birds and small mammals that are secondary consumers.

Carnivores that only eat meat, because their bodies cannot digest plant material, are called **obligate carnivores**. Cats are obligate carnivores. Humans are generally **omnivores**: we eat both plants and animals.

Some other specialised consumers:

- piscivores eat mainly fish;
- insectivores eat mainly insects; and
- cannibals eat meat of their own species.

Figure 6.1 Honey possums are unusual mammals, being nectarivores.
photo: Don Bradshaw

Activity guide

Activity 6.1 Understanding food production

Outline to students the concept of food production as a process that uses energy from the Sun's rays to make 'food'. Slides 1 – 7 of the presentation, *Introducing food*, steps through the process as follows:

- Energy comes from the Sun.
- Leaves absorb carbon dioxide from the atmosphere.
- Water is absorbed from soil by roots, passes up the stem and is distributed throughout leaves by veins.
- Plants use these materials to make sugar that contains energy from the Sun.

An important step highlighted in this presentation is liberation of oxygen into the atmosphere by leaves.

Activity 6.2 Understanding food consumption

Slides 8 – 10 of the presentation steps through the process of consumption by animals as follows:

- Animals are unable to absorb energy directly from the Sun.
- Instead they may eat leaves that contain the Sun's energy trapped as sugar.
- The process of obtaining energy from sugar requires oxygen from the atmosphere (What put oxygen into the air?) and water. How do oxygen and water get into an animal? With both oxygen and water, an animal digests leaf sugars (food) and liberates energy contained in them.

The presentation also highlights liberation of carbon dioxide from food back into the atmosphere. How does this carbon dioxide get into the atmosphere? Do students remember what takes in carbon dioxide to make food?

Activity 6.3 Classifying food consumption

Outline terminology for defining food sources: herbivore (those that eat plants); carnivore (those that eat animals); and omnivore (those that eat both plants and animals). Place words on word wall.

Working with the last part of the presentation, students identify food that they eat as herbivores (leaves, stems, buds, flowers, seeds and nuts). Students who eat meat are identified as carnivores (can discuss here the source of the meat) and those that eat both meat and vegetables are identified as omnivore.

Other food items they suggest may be discussed and entered into their individual classification.

Most humans are omnivores, but some animals eat only nectar and pollen from flowers (honey possum: nectarivore). Some animals eat only fruit (fruit-eating bat: frugivore). Cockatoos eat mostly grains or seeds (granivore).

Activity 6.4 Identifying eaters and what they eat in their bush

Students use books and Internet to research types of food eaten by the eaters in their ecogram (eg kookaburras eat meat such as lizards and worms; invertebrates eat each other or leaves; cockatoos eat seeds; honey possums eat pollen and nectar).

Students make a T-chart that lists eaters in their ecogram in one column, and identification of their food items in the adjacent column. These charts will be used for making connections in **Part 7: Connections**.

As an extension activity students may prepare a table that groups eaters under headings: herbivore, carnivore, nectarivore, granivore or omnivore.

Figure 6.2 Sundew (*Drosera* sp.)
photo by Anne Matei, Environmental Research Group Augusta

Figure 6.3 Pink sundew
photo by Kingsley Dixon, Kings Park and Botanic Gardens Authority

Figure 6.4 Pygmy sundew
photo by Kingsley Dixon

CONNECTIONS

Banksia grandis bush
photo by Roger Crabtree

Purpose

This resource introduces students to how components of the bush are linked through mutual dependencies.

Outcomes

Students understand that:

- there are connections between the various components of the bush;
- factors that affect one component may have affects on other, linked components.

Materials needed

NAME	DESCRIPTION	LOCATION
Introducing connections presentation	This presentation may be used by teachers to introduce two types of connections found in the bush: producers and consumers; and connections related to life cycles of plants and animals.	digital-resources/presentations
tape		
large plastic rubbish bags		
certificates for bush scientists		**Appendix H** digital resources/templates

Activity summary

These activities are best spread across two class periods.

ACTIVITY		POSSIBLE STRATEGY	SUGGESTED TIME
7.1	**Making connections** Students use information on producers and consumers to add connections to their ecogram.	class activity	60 min
7.2	**What if?** Guided by the presentation, *Introducing connections*, teachers encourage students to consider consequences of removal of a single element from the ecogram.	class discussion	60 min
7.3	**Story making and communicating** Students create their own bush story.	class activity	60 – 120 min (optional)
7.4	**Participation in the program** Students are rewarded for participation in 'Be a Bush Scientist'.	class activity	10 min

Background for teachers

Re-creating a natural environment in a classroom provides an opportunity to study the bush as an ecosystem. What is an ecosystem? In simple terms, it is a community of living organisms in an environment of sunlight, soil and air that contain elements essential to life. Each feature of an ecosystem interacts with others, such as plant/animal, soil/plant, animal/animal or climate/plant relationships, to give some examples.

Interaction between members creates a dependency of one upon another. A slight change in one feature can disturb many others. Introduction of a non-native species, for example, reduces the number of native species, either by killing them (cane toads) or by out-competing them for food (rabbits). The lost species will have had important roles in the environment before cane toads and rabbits arrived (e g food for others). These roles will be affected and ramifications spread further.

Long-term change in the environment may constitute another disturbance. Plants and animals have evolved reproductive strategies (such as how many young they produce each year, and how often) to coincide with favourable aspects of climate. Changes in weather disrupt these patterns and reduce reproductive rates.

Living matter in an ecosystem could be thought of as a reservoir of food energy. Organisms either produce food or they devour it. Energy is not lost — it just passes from one to another.

A more complex system will have a greater number of organisms, with many performing similar functions. Provision of food, for example, by many organisms protects an ecosystem from loss of a particular food. More than one pollinator protects against the loss of one. So there is strength in numbers.

Some plants, however, have specialised their anatomy to a great degree in order to attract a particular pollinator and in at least one example have limited themselves to a single pollinator (e g hammer orchids). Loss of the thynnine wasp may spell doom for the continuation of hammer orchids.

Nectar-producing plants in south-west Australia depend on honeyeaters, invertebrates and honey possums for pollination. There is no information on whether the highly specialised honey possum, with its tiny size and mobility, is a particularly effective pollinator of banksias, but presence of invertebrates in ecosystems may buffer against the loss of honey possums. What is evident is a greater capacity to buffer against loss and disturbance in an ecosystem that has a high level of biodiversity.

The important concept to be gained from this lesson is the inter-dependence of one element in the bush upon another, whether it is for shelter, pollination or food supply.

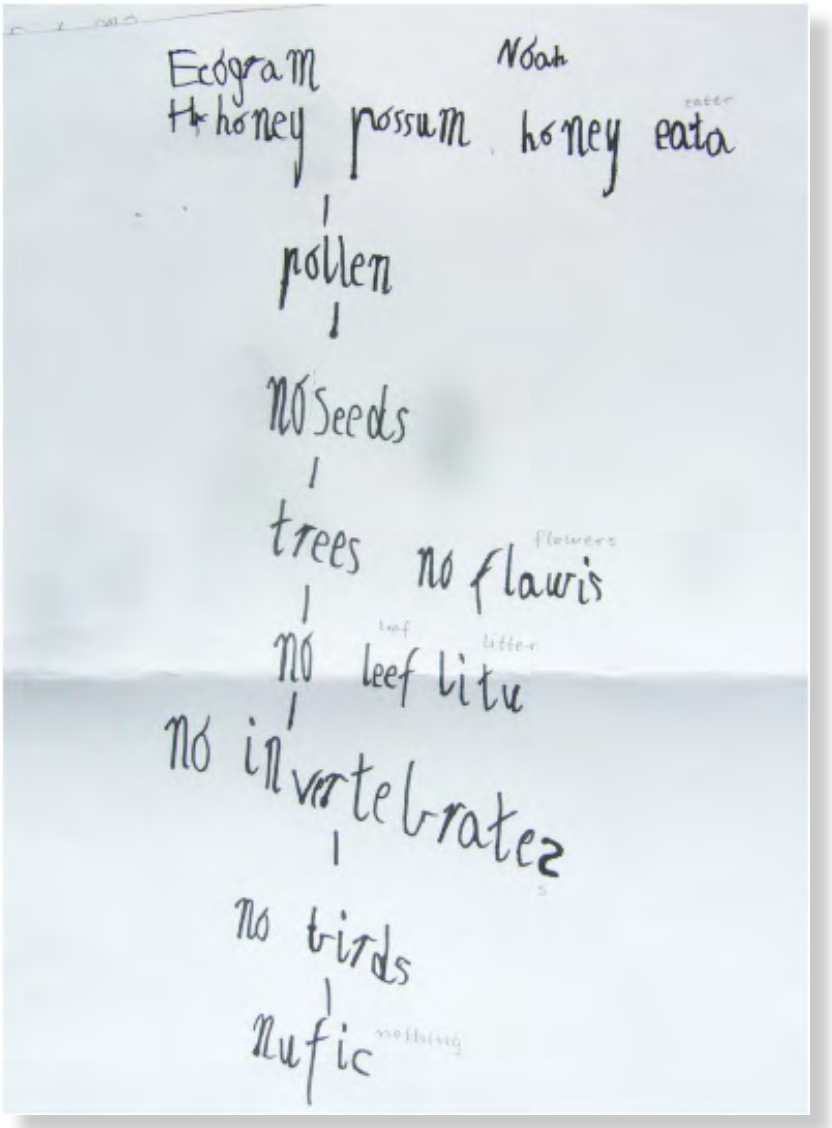


Figure 7.1 Consequences of removing elements from the Australian bush, as represented by a Year 1 student.

Activity guide

Activity 7.1 Making connections

Students make a T-chart listing the components of the bush and what they make. This includes: What makes litter? (trees); What makes seeds? (pollen); What carries pollen? (honey possums, honeyeaters, bees); What makes trees? (seeds); What makes nuts? (flowers).

Work with students to make connections, using tape, between these components on their ecogram, as in Figure 7.2.

- What makes litter? *Trees drop their leaves, so connect trees with litter.*
- What makes seeds? *Pollen, so connect pollen with flower.*
- What carries pollen? *Honey possums, bees and honeyeaters, so connect these to flowers.*
- What makes trees? *Seeds, so connect seeds with trees.*
- What makes nuts? *Flowers, so connect flowers with nuts.*

Students revise their T-chart constructed in **Activity 6.4 Identifying eaters and what they eat in the bush.**

Work with students, again using tape, to make connections between eaters and what they eat as shown in Figure 7.3.

Photograph ecogram wall (Figure 7.4).

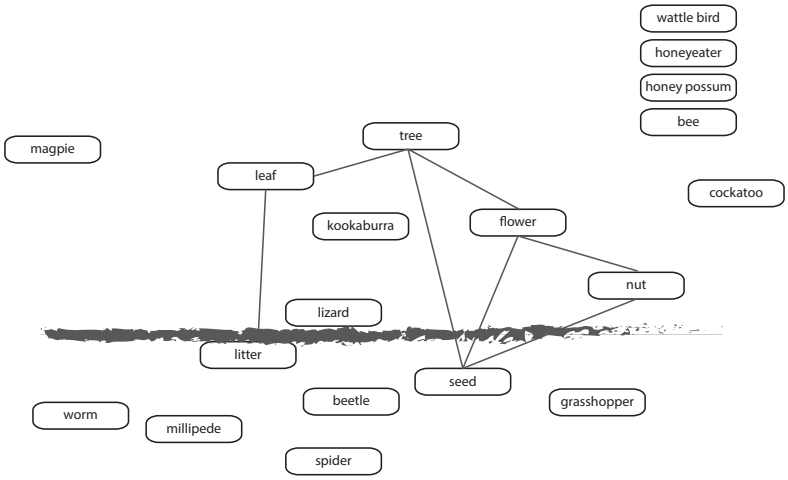


Figure 7.2 Adding 'What makes what?' connections to an ecogram.

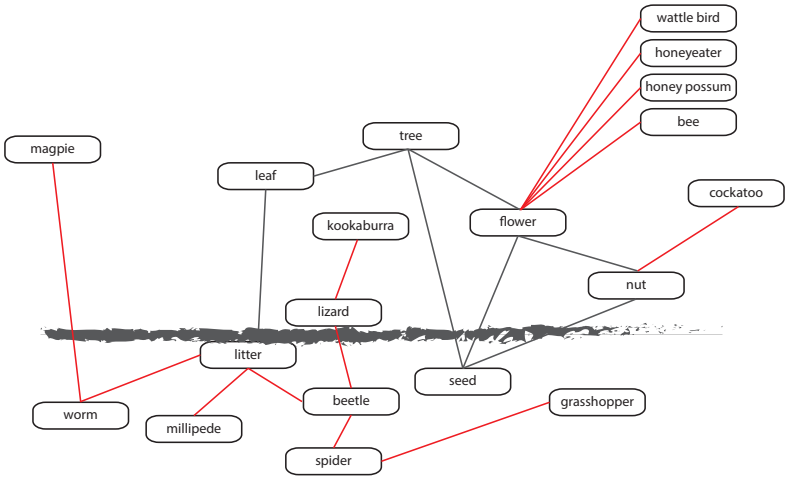


Figure 7.3 Adding 'What eats what?' connections to an ecogram.

Figure 7.4 A completed ecogram by Year 1 students at Woodlands Primary School. photo: Felicity Bradshaw

Activity 7.2 What if?

Working with the presentation, *Introducing connections*, this activity comprises the sequential removal of elements, based on their connections to other elements.

For example, if there are no pollinators then there are no seeds; no seeds then no plants; no plants then organisms that feed on them are removed; and so on.

Have large plastic bags for items to be returned to the bush (leaves, litter); or recycling (paper). Drawings may be kept by students.

Discuss with children what would happen if honey possums, bees and honeyeater birds are removed from the ecogram?

Without these pollinators, there will be no pollination of the flowers.

Remove pollen and flowers.

Without pollination of flowers, there will be no seeds.

Remove seeds and nuts.

Without seeds, there will be no food for cockatoos (granivores).

Remove cockatoos.

Without seeds, no new trees will grow.

Remove trees (save for display).

Without trees, there will be no leaves to form litter, which provides food and shelter for invertebrates.

Remove litter and invertebrates.

Without invertebrates there will be no food for carnivorous birds.

Thus, removal of pollinators means many other plants and animals will die.

Activity 7.3 Story making and communicating

Students create their own story about the ecogram, highlighting parts that are important to them.

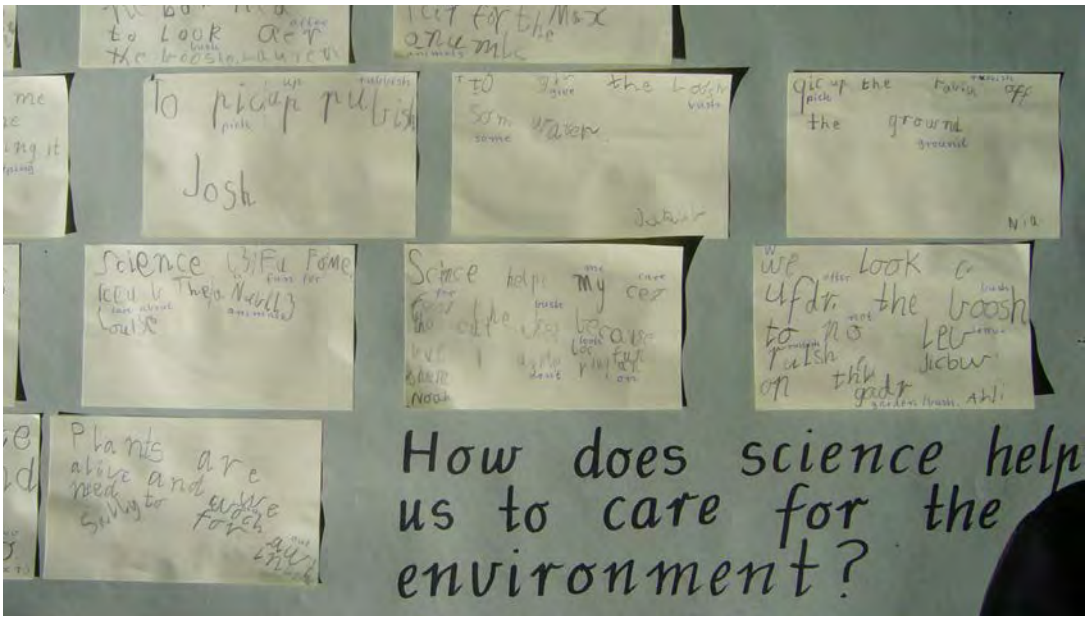
Provide a range of finger puppets (insects) and hand puppets (birds, possums and lizards) with which to tell this story.

Students adopt roles of animals and plants in the bush and create a pageant that highlights life in the bush, as they now understand it.

Activity 7.4 Participation in the program

Prepare a certificate for each student, rewarding them for *Being a Bush Scientist, Level 1*.

Figure 7.5 How does science help us to care for the environment? Responses from Year 1 students at Woodlands Primary School. photo: Felicity Bradshaw



Appendix A: How to make *My bush notebook*

To be added.

This will contain instructions for making *My bush notebook*, using the template found in digital-resources:templates.

Students may cut out pictures of trees using *Bush trees* (also found in digital-resources:templates) and stick them onto blank pages in their notebook.

Appendix B: Bush library

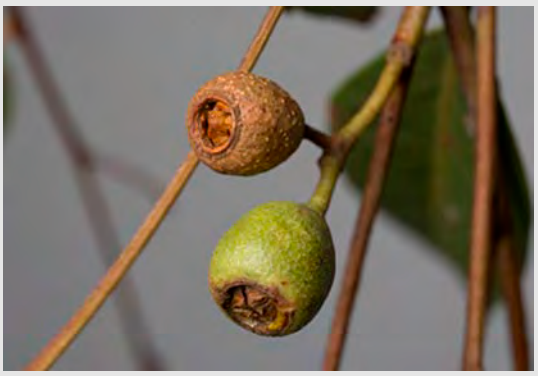
banksia (Noongar names: *piara*, *biyara*)




photos: Margaret Owen (flower) and Felicity Bradshaw

Jarrah (Noongar names: *jarrah*, *djarrah*)



photos: Felicity Bradshaw (flower) and Paul Ricketts

Marri marri (Noongar names: *marri*, *kardan*, *mari*)




photos: Paul Ricketts

Tuart (Noongar names: *tuart*, *doowart*)




photos: Ilena (flower), Michael Wheatley (nuts) and Paul Ricketts (bark and leaves)

zamia (Noongar names: *djiridji, biyoo, boyoo*)




photos: Paul Ricketts

grass tree (Noongar names: *balga, balka*)



photos: Don Bradshaw (flowers), Felicity Bradshaw (seed follicles) and Paul Ricketts

sheoak (Noongar names: *kondil*, *kwerl*)

photos: Michael Wheatley (flowers) and Paul Ricketts (bark and nuts)

paperbark (Noongar names: *bibool*, *modong*)

photos: Paul Ricketts

Peppermint (Noongar name: *wanil*)




photos: Felicity Bradshaw (flowers) and Paul Ricketts

Wattle (Noongar name: *kalyang*)




photos: Forest and Kim Starr (seed pods) and Felicity Bradshaw

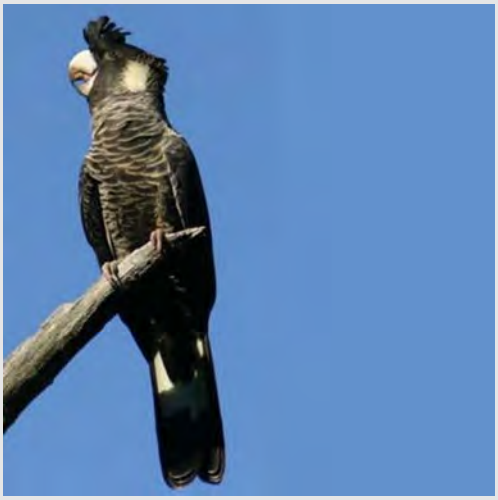
some common birds of southwest Western Australia

Australian raven
photo: Julian Phillips

black-faced cuckoo shrike
photo: Clive Nealon

blue wren
photo: Roger Crabtree

brown honeyeater
photo: Tom Tarrant (www.aviceda.org)



Carnaby's cockatoo
photo: Peter Head

golden whistler
photo: Paul Walbridge

New Holland honeyeater
photo: Stephen Hopper

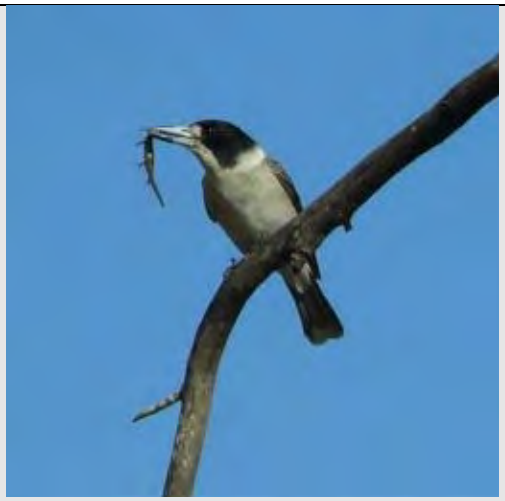
grey fantail
photo: Tom Tarrant (www.aviceda.org)

kookaburra
photo: Paul Walbridge

magpie lark
photo: Tom Tarrant (www.aviceda.org)

magpie
photo: Don Bradshaw

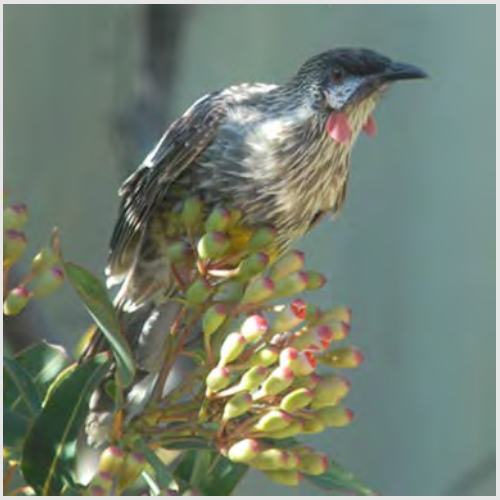
Western rosella (male)
photo: Kingsley Dixon



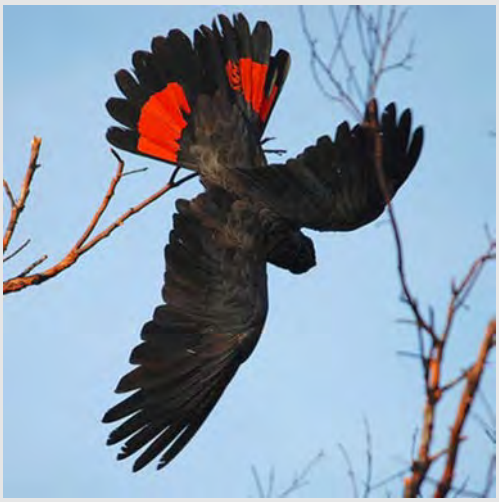
grey butcher bird
photo: Marlene Lyall

osprey
photo: Don Bradshaw

pink cockatoo
photo: John Milbank



red wattle bird
photo: Stephen Hopper



red-tailed black cockatoo
photo: Margaret Owen

ringneck parrot
photo: Don Bradshaw

silvereye
photo: Paul Walbridge

singing honeyeater
photo: Peter Head

sulfur-crested cockatoo
photo: Duncan Coles

willie wagtail
photo: Peter Head

Appendix C: Master data table (plants) — example

AREA 1						
STUDENT	GRASS TREE	ZAMIA	BANKSIA	SHEOAK	TUART	**TOTAL**
Alex	0	21	14	10	0	**45**
Sally	0	15	17	14	1	**47**
Dylan	0	2	11	6	2	**21**
Lucas	0	7	16	11	2	**36**
Jessica	0	7	15	7	0	**29**
Jakub	0	4	11	7	2	**24**
Ruby	0	10	10	4	4	**28**
Jake	1	10	13	7	1	**32**
Bailey	0	0	7	4	6	**17**
Mia	3	17	9	10	5	**44**
Paige	0	7	6	4	6	**23**
Noah	0	11	17	8	8	**44**
MEDIAN	**0**	**9**	**12**	**7**	**2**	**30**
AREA 2						
STUDENT	GRASS TREE	ZAMIA	BANKSIA	SHEOAK	TUART	**TOTAL**
Noa	3	7	0	1	1	**12**
Lauren	3	7	1	4	5	**20**
Max	6	2	0	1	3	**12**
Alexander	3	10	12	2	0	**27**
Ashli	10	15	10	15	15	**65**
Hayden	1	10	0	1	2	**14**
Sophia	3	6	1	1	0	**11**
Josh	3	6	1	11	3	**24**
Isaac	2	6	3	5	0	**16**
Nia	3	4	0	1	3	**11**
Edward	3	9	0	1	0	**13**
Louise	2	3	1	2	5	**13**
MEDIAN	**3**	**7**	**1**	**2**	**3**	**16**

Table 1: Student tally of number of trees in each area (calculated values in red)

AREA	GRASS TREE	ZAMIA	BANKSIA	SHEOAK	TUART	TOTAL
AREA 1	0	9	12	7	2	30
Area 2	3	7	1	2	3	16

Table 2: Median of each tree type, in each area

Appendix D: What invertebrate is it?

worksheet

What invertebrate is it?

START HERE

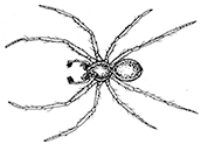
1. Does it have legs?

YES	go to **3**
NO	go to **2**

2. Does it have a shell?

YES	It is a SNAIL
NO	It is an EARTHWORM

3. How many legs does it have?



6 LEGS	go to **4**
8 LEGS	It is a SPIDER
LOTS OF LEGS	go to **9**

4. Does it have wings?

YES	go to **5**
NO	go to **7**

5. Are the wings coloured or white?

YES	It is a BUTTERFLY or MOTH
NO	go to **6**

6. How many wings does it have?

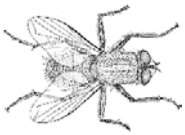
2 WINGS	go to **8**
4 WINGS	go to **12**

7. Is its body divided into parts?

YES	It is an ANT or TERMITE
NO	It is a CATERPILLAR


8. Does it have hard covers over its wings?

YES	It is a BEETLE
NO	It is a WASP, BEE or FLY

9. Does it have lots of legs and curl up into a ball?

YES	It's a SLATER (also called a WOODLOUSE)
NO	go to **10**

10. Does it have nearly 100 legs?

YES	It is a CENTIPEDE
NO	go to **11**

11. Does it have lots and lots of legs?

YES	It is a MILLIPEDE
NO	I'm not sure what you have found. Maybe your teacher knows.

12. Are the wings folded back?

YES	It is a GRASSHOPPER
NO	It is a DRAGONFLY


Appendix E: Master data table (animals) — example

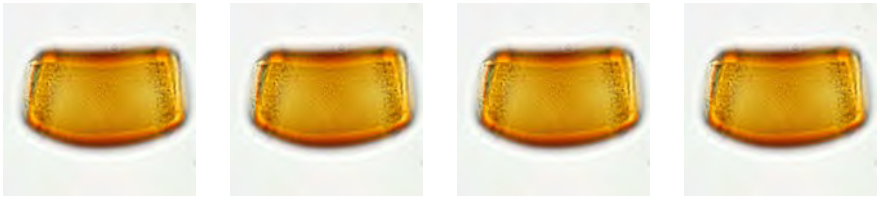
AREA 1											
TRAP ID	Name	beetle	spider	ant	millipede	earthworm	slater	earwig	grasshopper	sandgroper	**TOTAL**
A1	Alex	1	1	1	6						9
A2	Sally	2		2	3						7
A3	Dylan	1	2	1	9						13
A4	Lucas	1			8						9
A5	Jessica		1		6						7
A6	Jakub			1	4						5
B1	Ruby	3			5		4				12
B2	Jake	2			5						7
B3	Bailey	3			2						5
B4	Mia	4			1						5
B5	Paige	3									3
B6	Noah	2		1	4						7
	TOTAL	22	4	6	53	0	4	1			197
AREA 2											
TRAP ID	Name	beetle	spider	ant	millipede	**earthworm**	**slater**	**earwig**	**grasshopper**	**sandgroper**	TOTAL
C1	Noa										0
C2	Lauren	1			2						3
C3	Max				1			**1**			2
C4	Alexander	2			3		**1**				6
C5	Ashli	2		2						**1**	5
C6	Hayden		1		2						3
D1	Sophia				2						2
D2	Josh		1	1	5						7
D3	Isaac		1		2						3
D4	Nia		1		7				**1**		9
D5	Edward				1						1
D6	Louise	1			2						3
	TOTAL	6	4	3	27	0	1	1	1	1	96
GRAND TOTAL											296

Table 3: Student tally of number of invertebrates in each area (calculated values in red)

LEAF	TREE NAME	SURFACE *soft, leathery*	EDGE *smooth, spiny*	SHAPE *thin, wide, palm-like*	LENGTH cm	WIDTH cm	AREA cm^2 or number of squares
	gum tree	*smooth and waxy*	*smooth, sharp pont on end*	*long and narrow*	*13 cm*	*2 cm*	*26 squares*
1							
2							
3							
4							
5							

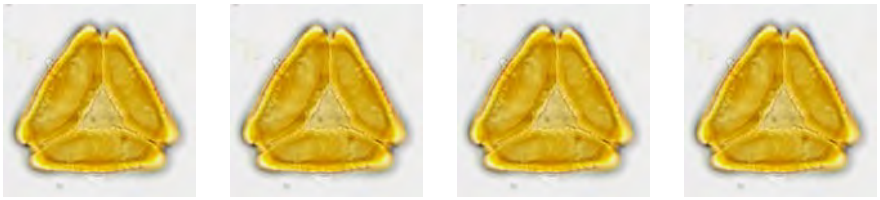
Table 4: Example leaf worksheet for student activity

Appendix G: Pollen library

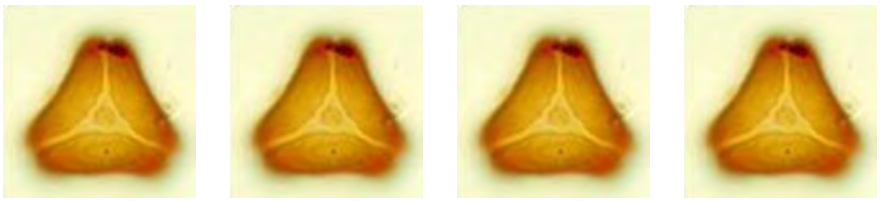


Banksia

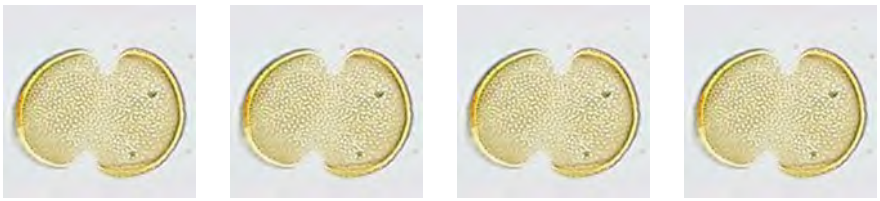
Banksia



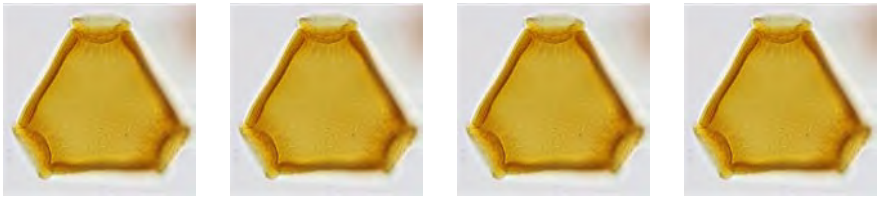
Marri



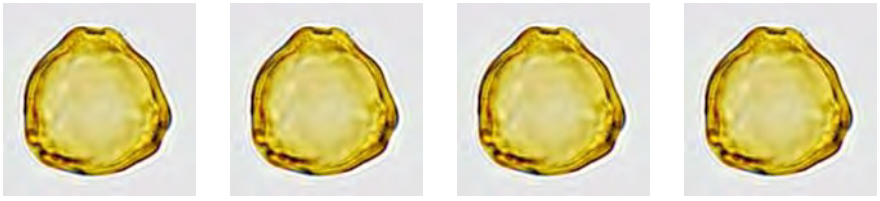
Tuart



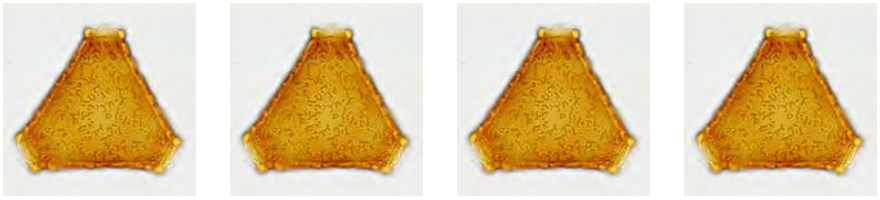
Grass tree



Hakea



Sheoak



Grevillea

Appendix H: Certificates and badges

See digital-resources:templates for files that can be used to create badges and certificates for students.