Australian Science Teachers Association

Australian Biodiversity

A resource book of ideas for teachers 2010

national science week

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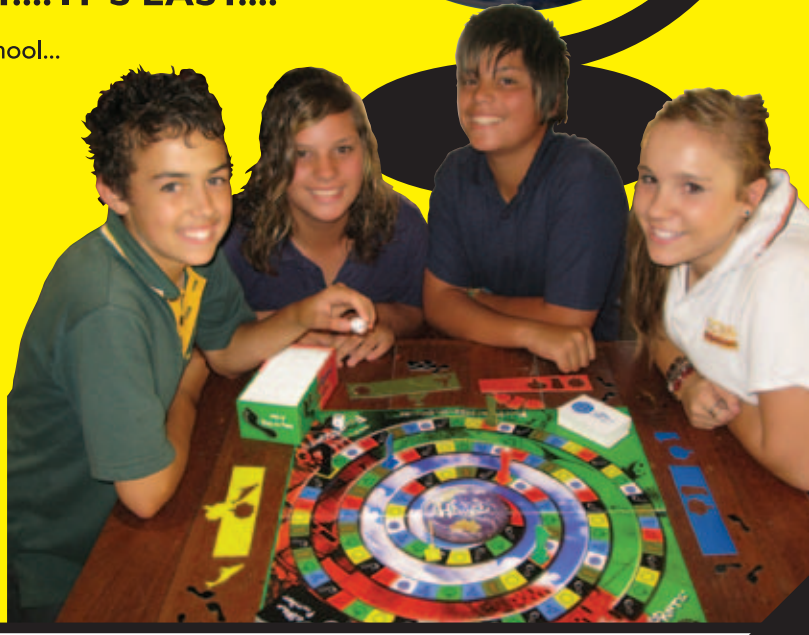

HOW TO REGISTER!

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Competition Freecall: 1300 912 347
Fax: Registration insert in the schools kit

FOR MORE INFORMATION OR TO PURCHASE FOOTPRINTS BOARD GAME CONTACT:

Chelsea Teelow, *Business Development Manager* Mobile: 0435 772 169 email: chelsea@signaturegames.com.au

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AUSTRALIAN SCIENCE TEACHERS ASSOCIATION

Look for the details and registration flyer inside the schools kit.

Minister's Foreword

Image: iStock

Australian teachers of science are instrumental in igniting the imagination of our young people and introducing them to the fascinating world of science. Eminent scientists constantly acknowledge the role their teachers played in starting them on a career in science.

ASTA continues to support and inspire teachers through the annual production of a teacher resource book to support school participation in National Science Week. This annual celebration of science is now in its thirteenth year and is anticipated to be larger than ever. We expect that more than 1,000 events will engage over half a million people throughout Australia during National Science Week 2010.

Australian Biodiversity celebrates the International Year of Biodiversity and offers schools an opportunity to focus the minds of young people and their communities on our unique natural and living environment … and its delicate balance. Despite a large documented decline in biodiversity over the last 200 years, Australia continues to be a megadiverse country and it is likely that there are thousands more new species yet to be discovered.

Many research scientists work tirelessly to help conserve species and ecosystems – including Ms Kathy Belov, winner of a 2009 Eureka Prize, who with a dedicated team is trying to protect the Tasmanian Devil from extinction from facial cancer. *Australian Biodiversity* showcases the achievements of Kathy and other Australian scientists, including those working on species and ecosystems not as well known as Australia's iconic marsupials and desert environments.

Australian Biodiversity is a valuable resource to promote community engagement with science. I encourage all Australian teachers to delve into its many pages of engaging activities and to involve their students and the broader community in National Science Week 2010.

My congratulations to all those involved in compiling this excellent resource for science education and awareness.

Senator Kim Carr
Minister for Innovation, Industry, Science and Research

Questionnaire

National Science Week 2010 Resource Book

Australian Biodiversity

COMPLETE THE QUESTIONNAIRE TO WIN

Australian Biodiversity is an ASTA resource book of ideas for teachers for National Science Week 2010. The information you provide will help ASTA make improvements to future publications.

YOUR NAME:

YEAR LEVEL YOU TEACH:

YOUR SCHOOL NAME:

YEAR LEVELS CATERED FOR AT YOUR SCHOOL:

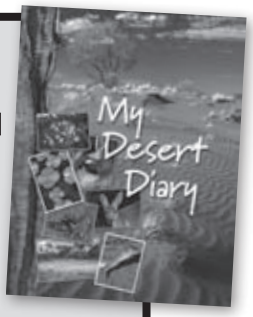
YOUR SCHOOL MAILING ADDRESS:

SCHOOL EMAIL ADDRESS:

ASTA MEMBER: (If yes which Science Teachers Association)

☐ YES ☐ NO

FAX/POST this evaluation form to ASTA by 20 September 2010 TO WIN 1 of 8 My Desert Diaries



My Desert Diary is a most unique book. A team of naturalists interpret their own sensory experiences to encourage you to engage more intimately with the living things you encounter. *My Desert Diary* highlights the unpredictable desert environment by sharing month-to-month changes you may observe in plants, insects, lizards, birds and fish. It presents a taste of the infinitely interesting interactions among species you may encounter in ten central desert destinations.

Kindly provided by:

ALICE SPRINGS Desert Park

Please indicate your ratings

FEEDBACK CRITERIA

1. Overall response to the book	**1**	**2**	**3**	**4**	**5**	
A valuable resource						Of little value
Well presented						Poorly presented
Information sections were helpful						Not helpful
Supports an inquiry approach to student learning						Does not support an inquiry approach
Applicable beyond National Science Week 2010						Not applicable
2. Resource Book Content	**1**	**2**	**3**	**4**	**5**	
Good balance of activities – primary to secondary						Too targeted
Includes activities relevant to the class level I teach						Irrelevant to my students
Created student interest						Little interest created
Provided a springboard to other ideas and activities						No scope for creativity
Additional resource links were useful						Not useful
Appropriate methodology						Inappropriate methodology

3. What did you find most valuable about the book? _____

Why? _____

4. What did you find least valuable about the book? _____

Why? _____

FAXBACK NOW: 02 6282 9477

MAIL TO: ASTA, PO Box 334, Deakin West, ACT 2600

Contents and Acknowledgements

ASTA and the authors would like to acknowledge the following people for their valuable advice during the development, writing and review of this book:

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In addition, we wish to thank the many scientists attached to universities, museums and Australian and State government agencies who gave freely of their advice during the research and writing of this booklet.

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PRESIDENT'S MESSAGE

The Australian Science Teachers Association (ASTA) is pleased to bring you *Australian Biodiversity*, the 2010 teacher resource book for National Science Week. The theme for National Science Week, and the teacher resource book, are generally related to the United Nations' International Year – 2010 being the International Year of Biodiversity.

ASTA has been involved with National Science Week for nearly 30 years and the publication of the teacher resource book for over 25 years.

ASTA acknowledges the funding support for this resource from the Australian Government through the Department of Innovation, Industry, Science and Research (DIISR). I would also like to acknowledge the significant contribution of the many people who contributed to the writing, editing and production of this book.

I'd like to thank each of ASTA's eight member Science Teacher Associations, through their National Science Week Representatives, for encouraging schools to be involved in activities during National Science Week.

We are continually revising the book and in 2010, there is a dedicated section for Early Childhood and a focus on providing information for schools to link with environmental organisations and their local community. Finally, I would like to encourage all teachers of science across Australia to use this resource to promote science, and Australia's unique biodiversity, within your local communities.

Anna Davis, President ASTA

Introduction

The booklet ***Australian Biodiversity*** has been designed to provide teachers with ideas to increase knowledge and understanding about the broad scope of Australian biodiversity and its unique place on the world stage, within the context of a celebration of National Science Week.

Studies of Australian biota in terms of its fauna and flora have been a traditional inclusion in the primary and secondary school curricula and the authors were very much aware that the Australian Science Teachers Association published a useful resource book with many excellent activities on biodiversity in 2001. Many resources are available to support the teaching of biodiversity *per se*, so this booklet's emphasis is on background knowledge and specific examples of biodiversity issues that illustrate and highlight the decisions necessary to conserve our unique Australian ecosystems.

National Science Week 2010 also provides an opportunity to celebrate Australian science and the many scientists involved in investigating, monitoring and conserving Australian biodiversity. Teachers are encouraged to include stories about these scientists in their classroom activities and share the excitement generated by the ongoing discovery of previously unknown species across this land of ours.

The conservation of Australian species, ecosystems and habitats is of interest to most members of every Australian community. Teachers are thus encouraged to make contact and have dialogue with local community organisations and Indigenous people wherever possible. Students should also be made aware of the opportunities for 'hands-on' engagement in community projects relating to protection of local species. Perhaps there is a community project that students could be part of during National Science Week?

HOW THIS BOOK IS STRUCTURED

This booklet has been structured to provide opportunities for teachers and students to develop an understanding of the background science of biodiversity as well as examples of the special nature of Australian biodiversity.

The book has been divided into chapters broadly based on:

1. Biodiversity Basics – the ways in which biodiversity can be described, measured and recorded. This includes some notes on classification protocols
2. Australian Biodiversity – including the origins of our unique biodiversity
3. Threats to Australian Biodiversity
4. Conservation of Australian Biodiversity – at ecosystem, species and gene level.

Biodiversity is a 'hot topic' in the media and the community in 2010 and organisations, local governments, state governments and the Australian government have responded by providing a wealth of information on the Internet. Where possible, complementary sites have been identified for each section and a list of further useful web links has also been developed (see page 48) that reviews some of the many outstanding sites on the World Wide Web.

ORGANISATION OF THE BOOKLET

In response to numerous requests, the first activities are designed for Early Childhood classes. However, Early Childhood teachers are encouraged to read through some of the later chapters to find other activities that can be adapted for their students.

Each of the remaining chapters is written for K-12 teachers and includes the following features:

- an introductory page which provides background information on the subject of the chapter
- a series of double-page spreads, each of which can be used independently of other pages.

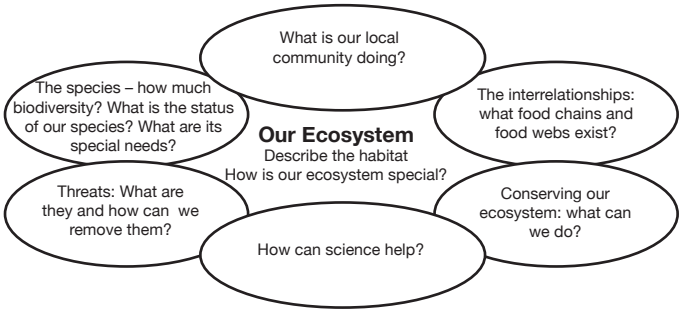
Each double-page spread consists of:

1. a single page of information about the header topic. This single page contains the background science knowledge and understandings relevant to the double page
2. a page of teaching activities. This page generally provides activities across four groups:
   - lower primary
   - primary
   - middle school
   - upper secondary

Not all groups are catered for in every set of teaching activities, so teachers are encouraged to read across all the activities for ideas that are appropriate to, or could be adapted for, their own students' specific talents, interests and levels of conceptual development.

CURRICULUM GUIDELINES

Ecosystems, species and genes, at appropriate conceptual levels, are common topics in Australian K-12 classrooms. The key message that this booklet hopes to send is that each individual species is NOT an island in itself. Perhaps teachers could select items from each of the chapters to map a unit of work along the lines of this diagram:



Whilst scientists might debate just how many species an ecosystem is able to lose without breaking down completely, all species within a habitat are interrelated and interdependent and any damage to the habitat will affect the interactions between species in that living community. However, as knowledge and understanding of the exact nature of species interrelationships within Australian ecosystems continue to be expanded, the onus is also on every one of us to maintain and conserve as many species as possible.

SAFETY AWARENESS

All the experiments included in *Australian Biodiversity* have been designed or selected to minimise hazards. However, there is no guarantee that a procedure will not cause injury. Teachers need to be aware of the special considerations surrounding biohazards in the classroom, ensure that students are suitably clothed for outdoor experiences, and observe the OH&S requirements of their own State or Territory. All necessary safety precautions should be outlined clearly to students prior to the commencement of any activity.

Community Contacts

AUSTRALIA WIDE

Australian Conservation Foundation (ACF)
www.acfonline.org.au

Bird Observation and Conservation Australia
www.birdobservers.org.au

Birds Australia
www.birdsaustralia.com.au

Bush Heritage Australia
www.bushheritage.org.au

Bushcare
http://svc018.wic008tv.server-web.com/page.asp?pID=80

Clean Up Australia *www.cleanup.org.au*

Conservation Volunteers Australia (CVA)
www.conservationvolunteers.com.au

Environmental Defenders Officer
www.edo.org.au

Field Guide to Frog Groups of Australia
http://frogs.org.au/groups/

Friends of the Earth
www.foe.org.au

Greenpeace Australia
www.greenpeace.org.au

Greening Australia
www.greeningaustralia.org.au

Landcare Australia
www.landcare.gov.au

Nature Keepers
www.naturekeepers.org.au

Oceania Project
www.oceania.org.au

Waterwatch Australia
www.waterwatch.org.au

Wilderness Society
www.wilderness.org.au

World Wide Fund for Nature (WWF)
www.wwf.org.au

NSW

Friends of the Botanic Gardens
www.rbgsyd.nsw.gov.au/friends

Friends of the Koala
www.friendsofthekoala.org

Nature Conservation Council of NSW
http://nccnsw.org.au

W.I.R.E.S (NSW Wildlife Information Rescue and Education Service) *www.wires.org.au*

QLD

Qld Conservation Council

www.qccqld.org.au

VIC

Clean Ocean Foundation
www.cleanocean.org

Environment Victoria
www.environmentvictoria.org.au

Friends of the Geelong Botanic Gardens
www.friendsgbg.com

Friends of the Gippsland Lakes
http://fogl.org.au

Friends of the Glenelg River
www.glenelgriver.org.au

Friends of the Helmeted Honey-eater
www.helmetedhoneyeater.org.au

Friends of the Prom
www.friendsoftheprom.org.au

ACT

Australian Network for Plant Conservation
www.anbg.gov.au

Friends of the Australian National Botanic Gardens Canberra
www.friendsanbg.org.au

Friends of Grasslands
www.fog.org.au

TAS

Environment Tasmania, The Conservation Council
www.et.org.au

SA

Conservation Council of SA
www.conservationsa.org.au

Friends of Parks Inc SA
www.communitywebs.org/FriendsofParks

Friends of Private Bushland
www.friendsofprivatebushland.org.au

Trees for Life
www.treesforlife.org.au

WA

Conservation Council of WA
www.conservationwa.asn.au

Friends of the Fitzgerald River National Park
http://fitzgeraldfriends.org.au

Friends of the Western Swamp Tortoise
www.westernswamptortoise.com

NT

The Environment Centre NT
www.ecnt.org/

Friends of Alice Springs Desert Park
www.alicespringsdesertpark.com.au/friends

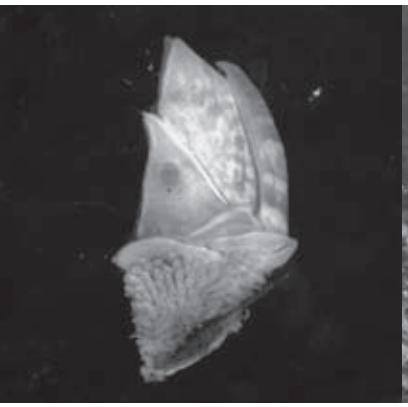
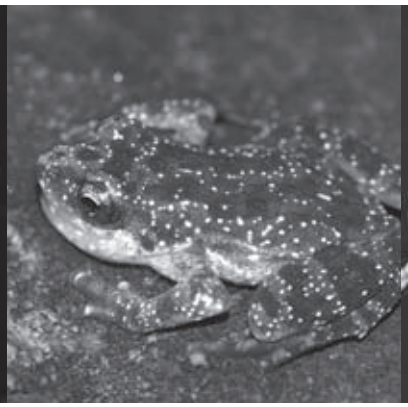
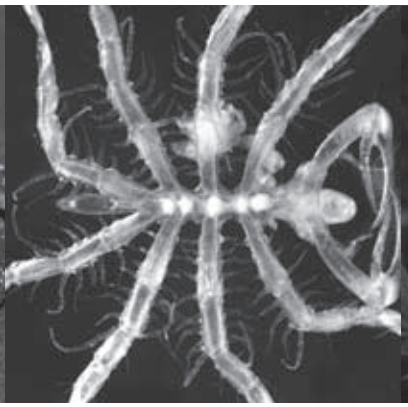
Volunteers in NT Parks
www.nt.gov.au/nreta/parks/volunteers/volunteers.html

BushBlitz
SPECIES DISCOVERY PROGRAM

Celebrate Australia's Biodiversity

TOP 10 NEW SPECIES COMPETITION – VOTE FOR YOUR NUMBER 1!

Australian species discovery scientists have nominated their Top 10 new species from 2009. The 'Top 10' is a fascinating and diverse group that includes a frog, a fungus and a fossilised fruit fly! What's more, you and your students have the opportunity to vote for your Number 1. There are prizes for primary and middle school classes and two senior secondary student winners will participate in a Bush Blitz survey.


Find out more about the Top 10 new species at *www.bushblitz.org.au* and then during National Science Week (August 14-22 *www.scienceweek.gov.au*) encourage your students to vote for their Number 1.

Australian Biodiversity for Early Childhood

The National Science Week theme of *Australian Biodiversity* lends itself to many activities for the early childhood years. Encourage the children to explore their surroundings and guide them to think about the relationship between their surroundings and the living things found there.

THE SCIENTIFIC METHOD

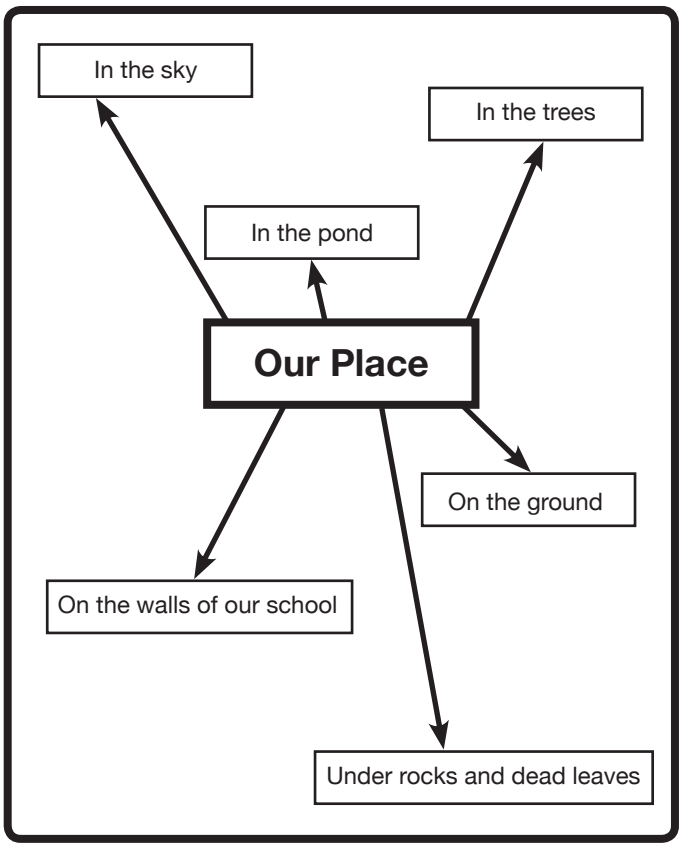
Consider using this National Science Week to guide your students through the process of working scientifically, which incorporates three aspects – Planning, Investigating and Evaluating. This promotes a scientific approach to learning, including:

- Using all the senses to make observations:
  - o What can they Hear? See? Smell? Feel?
  - o How can they tell the difference between a living and a non-living thing?
- Answering questions arising from these observations:
  - o Do all leaves smell the same?
  - o Why do birds have different songs?
  - o Are all parrots the same colour?
  - o How do I find out what these birds eat?
  - o Can I sort the things I have found into groups? How are they 'the same'? How are they 'different'?
- Undertaking and devising simple experiments:
  - o How can I find out if magpies sing the same song all the time?
  - o What types of plants grow in damp places?
- Understanding and demonstrating fair testing.
- Planning and conducting experiments incorporating fair testing.
- Recording – your students can record and report on what they find through:
  - o speaking, singing
  - o drawing, painting, collage
  - o puppet play, dance or dramatisation
  - o making models
  - o photos/DVDs
- Evaluating – use questions to lead your students into thinking about the impact of changes in their environment.
  - o What would happen if the food that the lizards eat (flies, insects) was not there?
  - o How could we attract more birds into our playground? (Different types of trees or shrubs perhaps?)
  - o What types of plants grow or would grow best in our playground?

Many ideas from the Lower Primary activities of this book can be adapted for Early Childhood. Two possible approaches are detailed on the following pages.

APPROACH 1 – OUR PLACE

Let the National Science Week theme of Australian Biodiversity lead the children's interest. What sort of places can you find for them to explore?



Biodiversity can be defined as the variation of life forms within a given boundary or location.

Find a location that could be investigated with your students. It could be small (the leaf litter near the back step, one rock pool) or large (the whole playground, an entire rock platform).

The types of organisms will vary. For assistance in identifying organisms, have a look at the following sites:

http://www.backyardnature.net/index.html Whilst US-based, this is an excellent site on which to find information about plants and animals. Start at the hyperlink 'Three Steps to Learning about Nature'.

http://www.sydneywildflowernursery.com.au/EDUCATION/BIOLOGY/biology.htm This site uses technical language but gives a good overview of the general classification schemes of living things.

http://www.backyardnature.net/names.htm has some accessible information about classification.

http://www.ento.csiro.au/about_insects/ has some useful and attractive pages on insects and their classification.

APPROACH 2 – THE THEMATIC APPROACH

Select a theme for National Science Week based around an organism (plant or animal) that is native to your area, and a colour, letter and sound that relate to it. Focus the lessons, stories, games, crafts and activities on that theme, including the concept that the living thing you are studying depends on being part of a larger community for its food, shelter and mates.

Example 1: A Week about Galahs

Australia has many different species of parrots and most of them are both colourful and noisy. They are a bird type that children may be able to see in the wild in any part of Australia. Whilst the galah has been used in this example, any parrot, even the pet budgerigar, can be used to exemplify the diversity of parrots in Australia.

Monday – Visuals and Stories about the Theme

Introduce the National Science Week theme to the children by reading a story or a poem that includes galahs.

- *Gilly's Faraway Flight (*Adams, 2007)*, ISBN 174162087-2* is a richly-illustrated story about a young galah and the other birds and animals it meets on a journey.
- *Silly Galah! (*Brian, 2001), *ISBN 1862914427* can be used to introduce the children to poetry, and is a great non-fiction resource about Australian animals.

Find a couple of pictures of the theme to help children learn visually. There is a photo you can use on a data projector at: *http://en.wikipedia.org/wiki/File:Female_Galah_Outside_Nest_crp.jpg*

Sing a song based on the weekly theme. For the musically talented, *http:///looselywoven.org/concerts/kids08/music/Gary%20Galah.pdf* has the music and lyrics to a song about Gary Galah.

Set up a bird wall with bird artefacts such as feathers, nests, images, and foods. If the classroom has a vocabulary board, print words about galahs on pieces of paper and post them on the board beside a picture of a galah. Include wings, tail, feet, head, and beak as well as feather.

Adult and juvenile Galah. Image: Stock.xchng

Tuesday – the Colour Associated with the Theme

Use the theme of galahs to introduce the colour pink. Ask the children to go around the classroom looking for everyday objects that are pink. This activity can be extended to talk about all the *shades* of pink.

Create a mono line drawing of a galah as a template for a picture for the children to colour in. Perhaps ask them to use a pencil to shade the galah where it is not pink or white.

Update the learning poster with a picture of the colour. If you have a colour poster of a galah, add the label 'pink' to its breast feathers.

Wednesday – the Letter and Sound Associated with the Theme

Your class can focus on the letter and sound of the week 'G for Galah'. Give each child a printout of the letter of the week to decorate and colour. If some children are more advanced with their alphabet, have them draw the letter themselves and colour it in.

Ask them to search the classroom and find the letter G on posters and books. Post the letter on the learning poster.

http://www.dltk-teach.com/minibooks/g/index.htm has a mini book *What begins with* G? for free download in either mono or colour.

Today can be the day when you talk about where the galah lives and what it eats. For a brief introduction to the bird, go to: *http://birdsinbackyards.net/bird/46* If you want to focus on sounds, this page also has a downloadable mp3 file of a galah's call. Perhaps your children would like to try to mimic the sound.

Thursday – the Number Associated with the Theme

Your class can also focus on a number for this week – perhaps one that relates to the number of pictures of galahs you have available.

Give the children a printout of the number to colour, or have them draw the number themselves. Perhaps that number of galah pictures can be coloured-in and pasted onto a sheet.

If you can obtain some wheat or corn seeds, the children could paste the number of the week as food around the feet of each bird.

Alternatively, use some cardboard boxes to make a tree hollow in which the galah can make its nest. What materials would the galah use in its nest? *http://galah.galahs.com.au/content/php/introduction.php* has useful background information.

Friday – Theme Wrap-up and Revision

Use the pictures of galahs to review the theme, colour, letter and number of the week.

Use the galah drawing from Tuesday as a template for a galah jigsaw puzzle. Provide the students with scissors, cardboard and glue to make their puzzle. If the glue dries in time, have them use a pink pencil or crayon to colour the pink parts of the bird.

You could make each child a booklet with his/her work for the week. Have a separate page for pictures of the galah and the colour, letter, and number of the week.

Finish with an activity that allows the children to act out the noise and flight of the galah, and sends them home to their worn-out parents completely hyped up!

Example 2 – A Week about Insects

Why not take the children for a walk outside and find evidence of insects? You might find exoskeletons that have been shed, galls on leaves, or cocoons in or on the bark of trees or in the forks of branches. There may even be the occasional caterpillar, the larval form of the insect. Where possible, bring them inside for a closer look and a talk about insects.

Do you have an insect table in your classroom? If cocoons are left undisturbed on their branch or in the bark, the adult insect may emerge. Can you bring examples into the classroom for students to observe?

Sequence the activities throughout the week in a similar pattern to that suggested for the galah. For example, adult insects have six legs, so the number of the week could be six.

Risk assessment:

1. *Check the 'tour' area first for ants' nests or evidence of larger ants or any other insects that can give a nasty bite.*
2. *Warn the children to be careful what they touch or pick up. Perhaps check with you first?*
3. *Make sure that you distinguish between insects and spiders; the latter are not insects and can bite.*
4. *Check your students for any specific insect allergy such as sensitivity to bee stings.*

Different types of insects may or may not go through a complete change in appearance (metamorphosis) during their life cycle. As National Science Week is in August, mature insects might not have emerged in colder regions. The ideas below are based on the assumption that it could be easier to find cocoons or chrysalises at this time of year.

1. *http://www.butterflyhouse.com.au/Be-Educated/Butterfly-Life-Cycle.aspx* has an accessibly-written and useful description of the life cycle stages of a butterfly.
2. If you need some background reading on the life cycles of various insects, *http://australianmuseum.net.au/Metamorphosis-a-remarkable-change* provides the biological details.
3. To get a sense of the broad range of insects in Australia, take the time to browse *http://www.lifeunseen.com/index1.php*
4. Are you interested in having a live insect growing in your classroom? Have a look at: *http://mycitygarden.com.au/category/live-insect-growing-kits/*

Some Resources on the Theme of Insects

The sites listed below have activities and downloadable materials for use in the classroom.

- *The Very Hungry Caterpillar* (Eric Carle, 1969) *ISBN-10: 0399226907; ISBN-13: 978-0399226908.* A classic, with over 12 million copies sold. *http://www.dltk-teach.com/books/hungrycaterpillar/index.htm* has a series of activities and downloadable templates based on this book.

  Eric Carle has written a series of books for children about animals. Whilst US-based, the stories can be used to introduce an animal type and then explore similar animals found in Australia. If you would like to get some ideas about how to use Carle's books, go to the 'Resources, FAQ, Newsletters, Games' section of his official website at *http://www.eric-carle.com/home.html*

- *http://museumvictoria.com.au/pages/2085/bugs-bugs-bugs-rhymes-music.pdf* is an eight-page downloadable document with a great variety of little poems, jokes and ideas for bug-related activities. If your focus is to be insects, leave out the snail, worm and spider stories.
- *http://www.det.nt.gov.au/__data/assets/pdf_file/0019/2629/BeautBugs.pdf* is a four-page document with a wealth of ideas for activities based on insects.
- *http://www.dltk-teach.com/minibooks/c/index.htm* has a downloadable mini-book with words beginning with C (for caterpillar, chrysalis and cocoon)
- *http://www.dltk-kids.com/crafts/insects/index.htm* has games, colouring pages, crafts, songs, stories and poems about insects.
- *http://www.cocoon.org/index.shtml* is a US-based site dedicated to cocoons and the life cycles of insects, with many articles, stories, cartoons, Flash animations and colouring pages.
- *http://www.brisbaneinsects.com/brisbane_wasps/Palmdart.htm* has some excellent photos and information about a species of wasp that builds nests of mud for its eggs. Once the larva grows to full size on its rations of spiders, it then builds a cocoon.

A Monarch caterpillar is shown in various stages of shedding until the skin falls away and a chrysalis begins to take shape. Image: iStock

A composite of various views of a Monarch butterfly emerging from its chrysalis. Image: iStock

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Biodiversity Basics

CHAPTER 1

Image: iStock

WHAT IS BIODIVERSITY?

Biodiversity is the term used to describe the variety of life on Earth and was coined from the combination of two words 'biological diversity'. The term can be used to describe the variation of life forms across:

- **a given ecosystem:** Eugene Odum, a founder of the concept of ecology, stated: *'Any unit that includes all the organisms (i.e. the 'community') in a given area interacting with their physical environment so that a flow of energy leads to clearly-defined trophic structure, biotic diversity, and material cycles (i.e. exchange of materials between living and nonliving parts) within the system is an ecosystem'*. Given the immensely complex and exquisitely sensitive nature of these interactions, any disruption within an ecosystem can strip it of its biodiversity within a short time span.
- **a biome:** This is a broad, regional type of ecosystem, characterised by distinctive climate and soil conditions and a distinctive kind of biological community, such as tundra or the arid lands of Australia.
- **the Australian continent:** It has been stated that Australia is the most environmentally megadiverse, developed country in that it supports about 8% of the Earth's total biodiversity. Australia's unique biodiversity can be partly attributed to the long-term isolation of our continent from other landmasses. More than 80% of Australia's species occur naturally only in Australia. This high number of endemic species is largely a result of its long period of separation from other continents.
- **the entire Earth:** The following paragraph is quoted from *http://australianmuseum.net.au/What-is-biodiversity It is estimated that there are 13.6 million species of plants, animals and micro-organisms on Earth. Australia has about one million of these, which represents close to 8% of the world's total and is more than twice the number of species in Europe and North America combined. Megadiversity describes countries with very high levels of biodiversity. Twelve of the megadiverse countries, including Australia, contain about 75% of Earth's total biodiversity. As a 'developed' nation, Australia has a special responsibility for biodiversity conservation and management. Other megadiverse countries include Brazil, Colombia, Ecuador, Peru, Mexico, Democratic Republic of the Congo, Madagascar, China, India, Indonesia and Malaysia.*

Mountain Ash Forest - an ecosystem. © Megan Muir 2009

Levels of Biodiversity

Biodiversity is often used as a measure of the health of biological systems. Biologists often define biodiversity as 'the totality of genes, species, and ecosystems of a region'.

The above definition of biodiversity gives a unified view of the three levels at which biological variety has traditionally been identified: *genes, species and ecosystems.*

A gene is usually regarded as the smallest physical unit of heredity. Chemically, it is a segment of DNA or RNA that is transmitted from one generation to the next, and that carries genetic codes for the manufacture of proteins essential for the growth and development of each living organism. Genetic diversity implies there is a great variety of genes that are present in a population. It is essential for the survival of a species because it maximises the adaptive potential of a species and reduces its vulnerability to environmental change.

A species is defined as a group of organisms capable of interbreeding and producing fertile offspring.

Adaptation describes the process whereby traits that are beneficial in terms of survival and reproduction become more common, and those that are harmful become more rare. The accumulation of differences in traits over successive generations leads to *speciation*, or the emergence of new species.

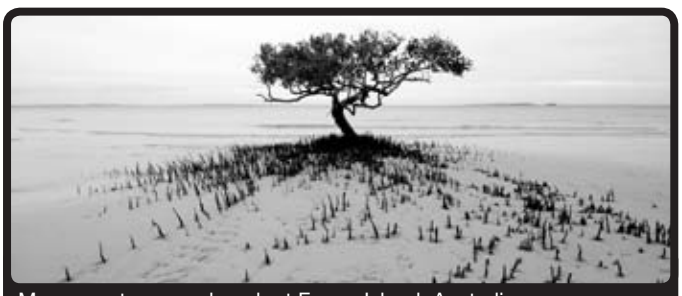
The process of adaptation and speciation over time is known as *evolution*. Put simply, evolution is descent with modification. The theory of evolution provides a unifying, logical explanation for the diversity of life.

Species are described in two ways with respect to their biodiversity:

- ***Species diversity*** refers to the number of species and their relative abundance and is useful in providing information about which species are common and which are rare.
- ***Species richness*** considers the number of species only and is a useful measure to describe how many species there are within a community or given area.

While the biodiversity of an area depends on local conditions, there are usually some general patterns. Species richness generally increases with area and variety of habitat within that area. A greater variety of habitat types allows for a greater variety of species. Species richness generally decreases with altitude, latitude and depth. As altitude and depth increase, factors such as oxygen availability, pressure, temperature and available energy affect richness.

An ecosystem is a biological community of plants, animals and other organisms living in an area which provides what they need in order to survive. The different species depend on the environment and the environment depends on them. An ecosystem can be as small as a tiny pool or as large as a huge desert.



Mangrove tree on a beach at Fraser Island, Australia. Image: iStock

CASE STUDY – MANGROVES IN AUSTRALIA

Mangroves are a unique and important component of Australian biodiversity. The distribution of mangroves provides an example of how biodiversity can show patterns with environmental gradients.

Australia has the third largest area of mangroves in the world after Indonesia and Brazil. A total of 43 mangrove species are found in Australia, representing 58% of the world's mangrove diversity. Queensland has the largest area of mangroves (44% of Australia's total), followed by the Northern Territory (37%) and Western Australia (17%).

Mangrove diversity generally decreases as latitude increases (i.e. moving south from tropical to temperate zones). North Queensland has more than 30 species of mangrove, while Victoria, South Australia and southern Western Australia have only one species and Tasmania none! This is due to the combined effect of three factors; temperature, rainfall and protection. Mangroves generally do not occur where the average temperature of the coldest month is below 20°C. Mangroves do occur in areas that are protected from strong wind and wave action and where there is high rainfall, run-off and sedimentation.

Far North Queensland and the Northern Territory have the highest mangrove diversity (19-32 species) in Australia. Both areas are located within tropical climatic zones that have a high rainfall and are buffered from strong ocean currents by the islands of Indonesia, Timor Leste, Papua New Guinea and the Great Barrier Reef.

Mangrove communities are important as they assist in coastal stabilisation, primary production and provision of nursery habitat for marine fish. Mangrove intertidal systems also provide habitats for a wide range of vertebrate and invertebrate fauna. These include bird and bat species that are largely restricted to mangrove and associated shoreline habitats.

Because of their ecological importance as coastal marine habitats, all mangrove communities are protected in New South Wales and Queensland. Mangrove communities are protected in some areas in Western Australia, the Northern Territory, Victoria and South Australia.

FURTHER REFERENCES

Biodiversity and its value (Australian Government DEWHA)
www.environment.gov.au/biodiversity/publications/series/paper1/what.html

What is biodiversity? (Australian Museum)
http://australianmuseum.net.au/What-is-biodiversity

Biodiversity and ecology overview (CSIRO)
www.csiro.au/science/Biodiversity.html

Genetic Diversity (World Resources Institute)
www.wri.org/publication/content/8585

Genetic diversity – Australian bryophytes (Australian National Botanic Gardens)
www.anbg.gov.au/bryophyte/case-studies/genetic-diversity.html

Evolution (PBS) *www.pbs.org/wgbh/evolution/*

Activities

Designed for all levels of schooling, the emphasis of these activities relating to biodiversity basics is on providing students with opportunities to learn about the levels of variation in living things.

A useful package for teaching Biodiversity

http://www.rbg.vic.gov.au/__data/assets/pdf_file/0003/6717/Biodiversity_Up_Close_School_Grounds.pdf

This booklet is a 73-page downloadable colour pdf booklet, with 13 activities relating to Victorian syllabus requirements. It begins by defining and describing biodiversity and includes activities for habitat assessment, flora and fauna surveys and future action. Well worth a look!

LOWER PRIMARY – PRIMARY

How are we the same? How are we different?

Human beings have many features in common such as location of hair, number of eyes, ears, noses, limbs, fingers, toes and other body parts.

Assist your students to draw up a list of features that can be used to describe and differentiate humans.

Do you have a digital camera handy that can be used to photograph each of the class members? Ask the students to look at pictures of themselves and their fellow students and discuss the ways in which they differ from each other. For older students, introduce the word 'diversity' to describe the pattern of differences.

MIDDLE SCHOOL

Biomes of Australia

Plants and animals that live naturally in a biome are adapted to that biome. The following website *http://www.kidcyber.com.au/topics/biomes.htm* cites seven generally accepted biomes: water, (freshwater or ocean), rainforest (tropical or temperate) tundra, desert, taiga (coniferous forests) deciduous forests and grassland. This site with its further links can be the starting point for your students in the activity below.

1. Ask your students to decide which of the listed biomes will be found naturally across Australia,
2. Divide the class into groups to research the conditions in one Australian biome.
3. For each biome, the group should then identify the general adaptations that are needed to survive in their chosen biome.
4. Ask each group to focus on ONE sample species (plant or animal) in their chosen biome and describe its life cycle and other adaptations that enable it to live where it does.
5. Each group should develop a presentation about the biome and its sample species that they have researched. This presentation may be a model, PowerPoint or poster.
6. Older students can be asked to predict what would happen to this plant or animal if the climate in its biome changed significantly.

http://www.environment.gov.au/parks/nrs/science/bioregion-framework/terrestrial-habitats.html has a map with the Australian ecoregions as well as notes about biomes.

Exploring an Ecosystem

If you are near a coastal community with mangroves, consider a field trip to examine the mangrove community.

1. The investigation during the visit can include:
   - Identifying habitats within the ecosystem
   - Counting species within the habitats – don't forget to include plants!
   - Identifying the physical features of the habitat
2. A mangrove ecosystem is different from many others in that the dominant tree species, the mangrove, is a terrestrial plant living in an aquatic environment. Challenge your students to find out about the adaptations that mangroves need to survive:
   - a lack of oxygen in the water
   - living with salty water (which would kill land plants)

*I*f it is not practical to visit a coastal mangrove community, consider a field trip to a terrestrial community.

1. Carry out the investigations in Section 1 above.
2. Alternatively, for terrestrial biological communities, ask students to investigate adaptations that allow organisms (including plants) to survive in low rainfall, high temperature environments.

http://www.kidcyber.com.au/topics/mangroves.htm is a suitable website for middle school students to begin an online investigation into mangroves.

UPPER SECONDARY

Exploring an Ecosystem

As with the Middle School activity, secondary students would benefit from a field trip to count and gather information about a local ecosystem. By providing recording devices such as cameras, as well as measuring equipment to allow estimation of size and numbers, students could be guided to explore the diversity of species (and genes, if diversity within a species is apparent) in a local ecosystem.

Mangroves

The importance of mangroves to both coastal terrestrial ecosystems and marine ecosystems continues to be studied.

By means of a webquest project, students could be asked to gather information and deliver a short presentation on aspects of mangrove biology such as:

- Specialised adaptations within the mangrove community
- Analysis of the distribution of mangroves within and outside Australian waters. What abiotic (physical) features of the environment determine the distribution of mangroves?

Suitable sites for this research include:

Mangrove Action Project
www.mangroveactionproject.org/mangroves

Australian Forest Profiles: Mangroves (Australian Government DAFF) *www.daff.gov.au/brs/publications/series/forest-profiles/australian_forest_profiles_mangroves*

Measuring and Recording Biodiversity

The biodiversity found on Earth today consists of many millions of distinct biological species, which are the product of nearly 3.5 billion years of evolution. These species are the key components of natural ecosystems that would not function if all their species were lost and are destabilised by the loss of even a few species. It is important to identify species and their roles in ecosystems.

RECORDING BIODIVERSITY – IDENTIFY THE SPECIES INVOLVED.

Taxonomy is the practice of classifying species. A unit of classification is known as a taxon and refers to a certain group of organisms, e.g. an order, genus or sub-species. The history of taxonomy mirrors the history of Science in that, as technology improved, changes occurred in the criteria used to classify organisms.

First attempts at taxonomy were based on *artificial classification*. Organisms were classified according to one or a few particular traits (such as colour). This type of classification ignored evolutionary relationships and became problematic when dealing with a large number of species because it is not hierarchical.

The first hierarchical biological classification system was developed by Carl Linnaeus, a Swedish botanist, physician and zoologist in the 18th century. His system consisted of three kingdoms (animal, vegetable and mineral), divided into classes, then into orders, genera and species. It was accepted by the scientific community and now forms the basis of modern classification.

The system has been tweaked over the years and the levels, starting from the top, are now: kingdom, phylum (subphylum, superclass), class (subclass, superorder), order (suborder and superfamily), family (subfamily), genus (subgenus) and species (subspecies). All species on Earth are classified within a kingdom, phylum, class, order, family, genus and species group. The categories in brackets are only used if the traditional groupings are insufficient to classify the species. The strength of the system is binomial nomenclature, i.e. every species is given a unique genus plus species name, which together identify the organism. That is 1,900,000 unique names and counting!

Traditional Linnaean classification is based primarily on morphological (anatomical) and physiological (biochemical) characteristics. This system underwent dramatic change with Darwin's Theory of Evolution, which classified species according to their evolutionary relationships. The development of genetics technology further revolutionised taxonomy. Genetic studies have revealed much more information about the relationships between species and have led to the reclassification of many species. The practice of classifying species according to evolutionary relationships is known as *phylogenetics*. The study of the relationships between species both past and present is known as systematics and is important in tracing relationships between living species and their fossil ancestors.

Nomenclature is the term used for naming species. There are strict rules governing the naming and classification of species and biologists must follow these rules when they are describing (naming) a species. Scientific names are derived mostly from Latin. Latin was chosen because it was an international language of scholarship in early modern Europe, and since it is no longer widely spoken, is a politically neutral language. The purpose of this was to create a universal unbiased scientific language.

The scientific name is usually selected to indicate some useful information about the species it is describing. For example, the *'longifolia'* in Acacia *longifolia* describes the species' elongated leaves. Often a species is named after the person who discovered it, for example *Wollemi nobilis* (the Wollemi Pine) after David Noble. Sometimes a scientist describing a species will name it after another prominent scientist of the time as a sign of respect and acknowledgement of his or her work. It is considered poor form in the scientific community to name a species after oneself!

MEASURING BIODIVERSITY – IDENTIFY THE NUMBERS OF SPECIES INVOLVED

Most ecologists use two criteria to quantify (measure and describe) biodiversity. One is *Species Richness*, which is the number of species in a community. The other is *Relative Abundance*, which is the evenness with which individuals are spread out among other species in a community. The analysis of the relationship between species richness and relative abundance provides a clearer picture of the state of the biodiversity of a given area.

With respect to species richness, a large number of individuals of each species is usually desirable but can sometimes reflect a loss of biodiversity. For example, a surge in the population of small rodents might mean that the area has a significantly reduced population of raptors, snakes or other predators.

Relative abundance, on the other hand, refers to how the numbers of species vary from one place to another. Relative abundance tells ecologists about the spread of species. This criterion becomes important when ecologists identify situations in which individual species are limited to small fragmented areas of an ecosystem, indicating that conservation measures may be necessary.

Measuring Biodiversity - first identify the species.

Activities

Exploring Biodiversity – a resource book of ideas for National Science Week 2001 can be downloaded from: *http://www.asta.edu.au/resources/national_science_week_resource* and is highly recommended for activities focusing on discovering and measuring biodiversity. From pages 13–33, the activities are roughly grouped into the following categories:

- Species diversity,
- Genetic diversity,
- Ecosystem diversity,
- Importance of biodiversity,
- Threats to biodiversity.

LOWER PRIMARY

A simple classification exercise that requires an old magazine or newspaper and scissors is described at *http://kidsactivities.suite101.com/article.cfm/classifying_and_sorting_fun* The initial activity can be followed up by using the hyperlinks to pages of colouring activities that can stimulate discussion about different types of animals. Another sorting game is described at *http://www.kindergarten-lessons.com/classification_games.html*

PRIMARY – MIDDLE SCHOOL

LandLearn

http://www.landlearn.net.au/index.html
Our food sources, clothing and other resources rely on healthy agricultural ecosystems with a rich biodiversity. LandLearn provides support for schools to incorporate studies of sustainable agriculture and natural resource management into the curriculum. The site has many useful curriculum support activities. For example, *http://www.landlearn.net.au/print/biodiversity1.htm* is a fully-supported activity on measuring biodiversity.

Classification activities

http://www.pbs.org/wgbh/nova/teachers/activities/2215_reef.html has instructions and a pdf for download that introduces students to classification procedures using the morphological features of fish. Many other links with ideas on teaching classification are available at: *http://www.nclark.net/Classification*

Webquest – Classifying Animals

http://www.cap.nsw.edu.au/bb_site_intro/stage1_Modules/whats_alive/whats_alive.html The task tells students: *You have been given an exciting job, your school is setting up a wildlife park in a section of the playground. You must choose and investigate five animals which could be put in the park and, of these, choose the three most suitable.*

Linneaus and the Australian link

http://www.environment.gov.au/biodiversity/abrs/publications/posters/linnaeus.html When your students are learning about the European exploration and settlement of Australia, remember to mention Daniel Solander. Solander, who was a student of Carl Linnaeus, was the naturalist on Captain James Cook's first around-the-world voyage from 1768–1771 and took the first major Australian plant collections back to Europe.

MIDDLE SCHOOL

LandLearn – Biodiversity – our food supply depends on it

An interesting fully-supported activity following on from the Primary activity: *http://www.landlearn.net.au/curriculum/documents/Biodiversity-Ourfoodsupplydependsonit.pdf*

What goes into naming a new species?

http://www.npr.org/templates/story/story.php?storyId=94886658 has anecdotes on naming new species. *http://blogs.worldbank.org/eastasiapacific/new-species-what-s-in-a-name* has a great story about a difference of opinion between Linnaeus and Siegesbeck, a German working at the St Petersburg Botanical Gardens. Siegesbeck had Linnaeus' books banned in Russia. Linnaeus retaliated by finding the most unattractive, stinking, small flower in his collection and naming it after Siegesbeck, thus recording his feelings for perpetuity. *http://www.sciencedaily.com/videos/2006/0307-name_that_species.htm* has a short clip (US-based) about new species and a story about asking schoolchildren to name them. Perhaps, as a Friday afternoon special, ask your students to 'design' a new plant or animal and give it a species name. They will need to justify the name they chose.

On Borrowed Time

http://www.publish.csiro.au/onborrowedtime/sections/ad_home.html This learning resource, based on David Lindenmayer's book *On Borrowed Time*, has four inquiry-based teaching and learning units and two decision-making interactives, which allow students to reflect, consider and make decisions relating to Australia's biodiversity. Well worth a visit as it offers literacy and numeracy exercises in a science context.

Aboriginal Use of Native Plants

This WebQuest explores the use of plants by Indigenous Australians and provides an opportunity to discuss alternate criteria for classifying plants. *http://sydney.edu.au/science/uniserve_science/school/quests/nativeplants.html*

UPPER SECONDARY

Measuring species richness – a modeling activity

http://gk12calbio.berkeley.edu/lessons/less_measbiodiv.html has a modeling lesson which is readily adaptable to the Australian classroom. It takes into account variations within a species and the relative advantages of adaptations from these variations. The lesson also models some of the fundamentals of the scientific method, such as random sampling and replication.

Mapping and Measuring Biodiversity – Australian research

The Arthur Rylah Institute for Environmental Research is a leading centre for applied ecological research and the biodiversity research base for the Department of Sustainability and Environment (DSE) in Victoria. The home page at: *http://www.dse.vic.gov.au/dse/nrenari.nsf/Home+Page/DSE+ARI~Home+Page?open* has details of current research being undertaken. In addition, a hyperlink *Research Themes*, on the RHS of this page, leads to a number of further pages, including *Mapping and Measuring Biodiversity*, which gives details about strategies used by scientists in specific case studies. Ask your students to describe the strategies used and suggest reasons why specific strategies are used for the species involved.

Species - Known and Unknown

Australia is one of 17 countries described as 'megadiverse' by the World Conservation Monitoring Centre, based on the number of species and degree of endemism within the continent.

The seventeen megadiverse countries are home to the majority of the Earth's species. The total number of accepted described species in the world is estimated to be close to 1,900,000. Worldwide, about 18,000 new species are being described each year. For the year 2007, 75% of these were invertebrates, 11% vascular plants and nearly 7% vertebrates. Australia alone has about 8% of the world's 1,900,000 species, based on the *Numbers of Living Species in Australia and the World* report 2nd Edition, Sept 2009.

According to the report quoted above, Australia is home to a total of 147,579 accepted described species. This includes 8,128 chordates including 386 mammal, 828 bird, 917 reptile, 227 amphibian and ~5,000 freshwater and marine fish species, 98,703 invertebrate, 24,716 plants including algae and bryophytes, 11,846 fungi and 4,186 'other' species.

These numbers are not definitive as new species are being discovered all the time. In the three years since the first edition of the report was produced in 2006, 1,184 vascular plant, 48 reptile, 8 frog, 8 mammal, 904 arachnid, 148 myriapod (millipedes and centipedes) and 60 sponge species (among others) have been described.

A 'new' species is not necessarily a species that has been recently discovered; sometimes previously known species are reclassified into new groups based on new information. Genetic studies have lead to the reclassification of many species as genetic data reveals more information about the relationships between species.

Whilst it is important to conserve and maintain species at risk in Australia, scientists realise that there may be many more species that will disappear simply because they have not been identified and thus their habitats are not protected. The *Bush Blitz* program is a three-year project to document plants and animals across Australia *http://www.bushblitz.org.au/*

DISCOVERING NEW SPECIES – A CASE STUDY

Stygofauna are aquatic animals that live in groundwater, such as aquifers and caves that contain water. **Troglofauna** are air-breathing terrestrial animals that live underground in caves and smaller air-filled voids beneath the ground. Stygofauna and troglofauna are specialized to underground life, and are typically pale with elongated appendages to help them navigate in complete darkness. Some species have been isolated underground for many thousands of years, and have completely lost their eyes. Stygofauna are found in many different types of groundwater environments including fresh and saline aquifers, caves in limestone, and within the smaller pore spaces, voids, cracks and fissures in virtually any other rock types. Over the last ten years, scientific research and biological surveys, often associated with environmental surveys conducted as part of mining exploration, have greatly increased knowledge about West Australian stygofauna to a point at which this state is known to be a world hotspot for such organisms.

Stygofauna are found in every Australian state, but is especially rich in Australia's arid regions where groundwater provides an important refuge. Troglofauna are also found across Australia in dark, humid, underground habitats. A recent review of species richness in Australia estimated 850 new species of subterranean invertebrates, including various small insects, crustaceans, spiders, worms and many others.

ACTIVITY

What's underground?

The following quote comes from *http://www.adelaide.edu.au/news/news35801.html*

"What we've found is that you don't have to go searching in the depths of the ocean to discover new species of invertebrate animals - you just have to look in your own 'backyard'," says Professor Austin from the Australian Centre for Evolutionary Biology and Biodiversity at the University of Adelaide.

"Our research has revealed whole communities of invertebrate animals that were unknown just a few years ago. What we have discovered is a completely new component of Australia's biodiversity. It is a huge discovery and it is only about one fifth of the number of new species we believe exist underground in the Australian outback."

Ask your students to explore the Internet for more stories about these underground fauna. For example, *http://www.dec.wa.gov.au/content/view/3253/1974/* has a series of hyperlinks to information about WA stygofauna, while *http://www.subterranean ecology.com.au* contains more detailed information, downloadable articles, links to other sites and and pictures of Australian subterranean fauna.

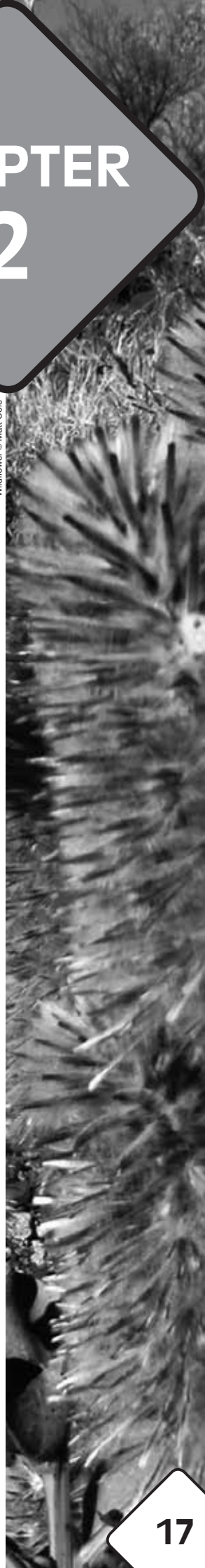
The key issues that they should identify and describe are:

1. What are these animals? What are their adaptations to life in underground waters and caverns?
2. What hypotheses have been put forward to explain their presence in underground waters?
3. Why is the conservation of these animals considered to be important?
4. There is potential for conflict between mining interests and conservationists over the protection of underground habitats. *http://en.wikipedia.org/wiki/Stygofauna* has a summary from both the mining and conservation perspectives and is a good place to start research for a discussion text on this issue.

Amphipod crustacean, *Nurina poulteri* Bradbury & Eberhard 2000. This stygofauna species is endemic to caves and groundwater on the Roe Plains which are part of the Nullarbor Plain, Western Australia. Length of amphipod is approximately 10 mm.

Australian Biodiversity

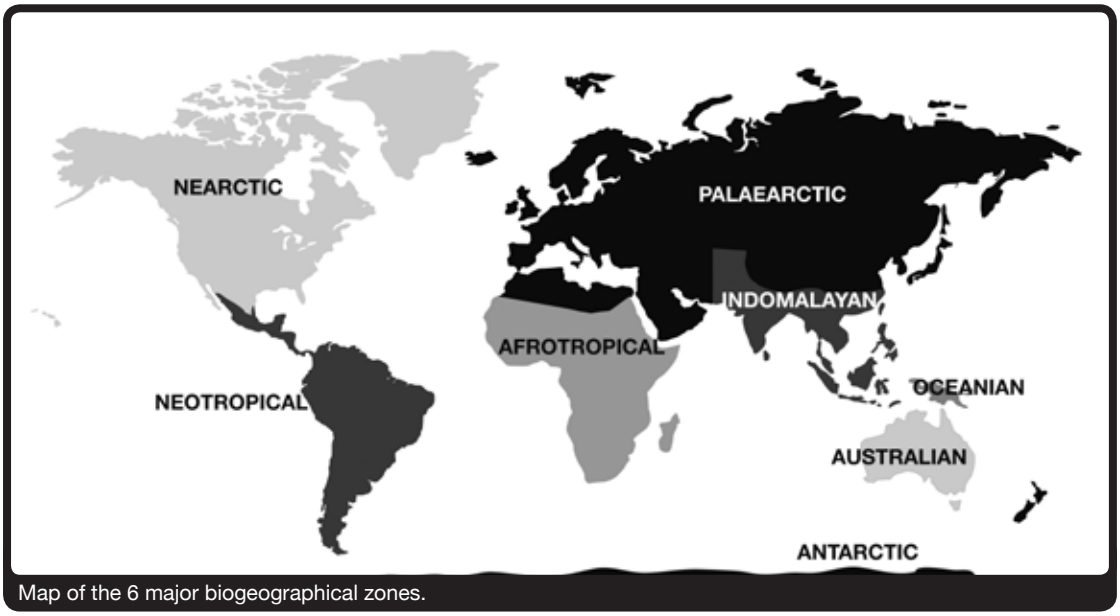
CHAPTER 2



Wildflower © Matt Cole

Biogeography is the study of where species are found and why. It can help us answer questions such as why are the Australian mammal fauna dominated by marsupials? Why are echidnas found only in Australia and New Guinea? Why does Indonesia, but not Australia, have tigers?

The distribution of species throughout the world can usually be explained through a combination of factors including speciation, extinction, continental drift, glaciation (with its associated changes in sea level), geography and available energy. The world is divided into six major biogeographical zones, one of which is the Australasian zone that includes Australia. Australia's biodiversity is different from the rest of the world because it has been geographically isolated for so long.



Map of the 6 major biogeographical zones.

About 260 million years ago (mya) the world's landmasses were assembled in a supercontinent known as Pangaea. Pangaea split in half about 200 mya, giving rise to two daughter landmasses – *Laurasia* in the northern hemisphere and *Gondwana* in the south. Laurasia and Gondwana continued to break and drift apart, eventually giving rise to the continents that exist today.

The Gondwanan break-up began between 125 and 150 mya and gave rise to Africa, South America, Antarctica, India, New Guinea and New Zealand plus assorted landmasses now attached to other continents. Australia and Antarctica were the last of the Gondwanan continents to break apart, remaining joined until as recently as 45 mya.

As Australia drifted northwards and Antarctica south, a deep rift valley formed along the southern edge of Australia, becoming the Southern Ocean. This rifting created Tasmania, which was pulled from the mainland as Antarctica headed south. After separation from Antarctica, Australia continued to head north, where it collided with New Guinea and the Timor region about 15 mya. This collision opened up land bridges between Australia and New Guinea, but these were cut by subsequent rises in sea level.

Australia's Gondwanan Heritage

Since Australia split from Antarctica 45 million years ago (mya), the continent has been drifting in isolation (except for the brief collision with New Guinea 15 mya), so Australian flora and fauna have essentially evolved in isolation from the rest of the world.

The Gondwanan climate was warm and wet and much of the landmass was covered in rainforest. The separation of Australia from Antarctica changed circulation in the oceans and led to the development of the Antarctic circumpolar current. The *late Miocene* (10.4–5 mya) was a time of global cooling and drying. Ice accumulated at the poles, sea-levels fell, rainfall decreased and rainforests retreated.

Australia's move northwards into warmer latitudes was countered by the Miocene cooling, thus keeping Australia's climate relatively stable so that some pockets of rainforest persisted. These Gondwanan rainforests in Australia include the most extensive areas of subtropical rainforest in the world, large areas of warm temperate rainforest and nearly all of the world's Antarctic beech cool temperate rainforest.

Many of Australia's rainforest plant and animal species remained relatively unchanged from their Gondwanan ancestors. Australia's rainforests have high concentrations of primitive (i.e. show traits characteristic of an earlier stage of evolution) species. Few places on Earth contain so many plants and animals which remain relatively unchanged from their early ancestors. It is for this reason that these rainforests have been given World Heritage listing.

ENDEMISM

The Australian continent's long isolation and long periods of climatic and tectonic stability involved only gradual changes and Australia's unique species slowly developed as these changes occurred. The word endemic is used to describe a species which is found ONLY in a particular area and nowhere else. 87% of mammals, 45% of birds, 93% of reptiles, 94% of amphibians, 24% of fish and 92% of vascular plants in Australia are endemic! This is a very high level of endemism and is caused by that long isolation.

Whilst the rainforest environments retained their ancient species, other parts of the continent placed pressures on species to adapt to much drier climates.

FURTHER READING

Gondwana Timeline: Geological History and Australian Flora (Australian Plants Society) *www.apstas.com/gondwanatimeline.htm*

Biogeography of Tasmania (Parks and Wildlife Service Tasmania) *www.parks.tas.gov.au/index.aspx?base=2893*

The late Miocene Epoch (10.4-5 million years ago) (Australian Museum) *http://australianmuseum.net.au/The-late-Miocene-Epoch*

Gondwana Rainforests of Australia (Australian Government DEWHA) *www.environment.gov.au/heritage/places/world/gondwana/index.html*

Gondwana: The Great Supercontinent (Parks and Wildlife Service Tasmania) *www.dpiw.tas.gov.au/inter.nsf/Attachments/SJON-5MD762/$FILE/Gondwana.pdf*

Wet Tropics Management Area *www.wettropics.gov.au/*

The Cycad Pages (Royal Botanic Gardens, Sydney) *http://plantnet.rbgsyd.nsw.gov.au/PlantNet/cycad/*

Endemism in Australian Mammals (Australian Museum) *http://australianmuseum.net.au/Endemism-in-Australian-mammals*

Endemic Plants (Parks and Wildlife Service Tasmania) *www.parks.tas.gov.au/file.aspx?id=6504*

Gondwanan Relics. © Megan Muir

CASE STUDY – CYCADS

An example of a Gondwanan rainforest relic species is the cycad. They are an ancient and primitive cone-bearing plant representing an evolutionary link between flowering plants and ferns. They dominated the vegetation landscape during the Mesozoic Era (251-65.5 million years ago) and are known as fossils from as far back as the Permian period (over 200 mya).

The Wet Tropics World Heritage Area in northern Queensland is the centre of diversity for cycads. It is the only place on Earth with the world's largest cycad (*Lepidozamia hopei*), which can grow more than 13m tall, and the world's smallest cycad (*Bowenia spectabilis*), only about 1.5m tall, growing alongside one another!

Cycads contain edible starches which can be extracted from the root, stem and seeds. Various species of cycads are used as food, or for ceremonial or medicinal purposes in Guam, Australia, India, Indonesia, Africa, Java, Columbia, Mexico, and Florida. However, the presence of toxic compounds means that special precautions must be taken before they can be eaten.

Indigenous Australians with access to cycads became experts at removing the toxins from them. For example, the people of eastern Arnhem Land collect the seeds of *Cycas orientis*, which is endemic to this area, sun-dry them for two days, chip them into small pieces, leave them in running water for five days and then pound the result into a coarse paste used to make damper or bread.

Aging the seeds is sometimes sufficient to remove the toxicity and allow them to be eaten raw or cooked. However, this method, used for *Cycas angulata*, which grows in northern Australia, requires skill to separate the edible seeds from those that contain high levels of the cycasin toxin.

Activities

PRIMARY – MIDDLE SCHOOL

Investigating the Mesozoic Era – The Age of Reptiles

Mesozoic Era	**Cretaceous** 146-65 mya
	Jurassic 208-146 mya
	Triassic 245-208 mya

This era in the Earth's history is the time when Gondwana was breaking up and is when reptiles were the dominant animal form. Most students will have heard of dinosaurs, but are they familiar with Australian dinosaurs?

Lead your students through an internet investigation with the following sets of questions:

1. What dinosaurs lived in Australia?
   Where have their fossil remains been found?
   http://www.abc.net.au/dinosaurs/meet_the_dinos/ozdino1.htm is a good place to start. For younger children, *http://www.kidcyber.com.au/topics/dinosOz.htm* has many links to further information.
   http://www.environment.gov.au/heritage/places/national/dinosaur-stampede/lark-quarry/environment.html is another useful page
   Display a large map of Australia and ask your students to draw the dinosaurs and pin them onto the map to show where they were found.

2. Lead them to consider what the dinosaurs ate. Many were herbivorous – what plants did they eat? What did the landscape look like in the age of dinosaurs? This set of questions will be harder to answer and your students will need to carry out a more in-depth search.
   For younger students,
   http://www.kidcyber.com.au/topics/dino_eras.htm has some information about the plants that grew during this era. Another page at this site links dinosaurs and plants *http://www.kidcyber.com.au/topics/dino_jurassic.htm*
   For older students and those with more advanced language skills, try the following sites:
   http://australianmuseum.net.au/The-Mesozoic-Era is one place to start, with the right-hand sidebars giving further descriptions of conditions in each of the Mesozoic periods.
   http://museumvictoria.com.au/prehistoric/time/plant.html has information on plants of the Jurassic period, when dinosaurs were at their peak.
   http://www.earthmuseum.see.uwa.edu.au/the_eocene_and_jurassic_gardens has images of the Eocene and Jurassic Gardens at the University of Western Australia.

3. Having collected information about both the dinosaurs and the plants, ask your students to construct a diorama to illustrate prehistoric life in Australia. Since the flora and fauna underwent change over the Mesozoic era, older students can be asked to focus on one period.
   Students who need help with this exercise can find an image to copy at: *http://www.environment.gov.au/heritage/places/national/dinosaur-stampede/lark-quarry/environment.html* Click on the thumbnail image.

Australia's Ancient Plants

Perhaps your students would like to plan and plant a Mesozoic garden as a long-term project? What plants can they find in nurseries that would have grown in the ancient Gondwanan landscape?

MIDDLE SCHOOL – UPPER SECONDARY

Biogeographical puzzles

Not all Australian species are endemic. If Australia has been isolated for so long, how did these species arrive in Australia?

Case 1: Boab trees

The Australian boab tree (*Adansonia gregorii*), found in the Kimberley region of Western Australia, is a biogeographical puzzle. The only other places in the world where boab species naturally occur are Madagascar and Africa. This is a puzzling distribution since Australia is nowhere near Madagascar or Africa and these landmasses separated early on in the Gondwanan break-up. Scientists originally thought that the Australian boab must have survived from a time when Australia and Africa were still part of Gondwana. However, genetic analysis revealed the Australian and African boab species to be very closely related; much more so than would be expected from a Gondwanan connection. The current theory is that Australian boabs originated from seed bought from Africa by some physical means such as ocean currents, birds, or even early human visitors!

Case 2: Elephant bird in Australia?

In 1993, a nine-year-old boy was on a family holiday on the foreshore of a Western Australian beach, and was digging in the sandhills. With his cousins, he dug up a 2,000-year-old fossilised elephant bird egg. Elephant birds have never been known in Australia but were found in Madagascar. The elephant bird was three metres tall and weighed 450 kilograms. The egg was huge – about 150 times the size of a chicken's egg. How did the egg get to Australia?

Case 3: Australian bats

Australia's bat fauna is diverse and covers many different habitats. There are over 90 species in Australia, with at least 30 of these being non-endemic (occurring on other continents as well as Australia.) So, in contrast to Australia's marsupials, the bats of Australia are not seen as unique. It is generally agreed that bats colonised the Australian continent from South-east Asia.

The three examples provided could be used to stimulate discussion about how non-endemic species arrived in Australia. Ask your students to research and develop an account of the ways in which terrestrial species arrived in Australia. Answering this question about animals might be easier than puzzling about plants!

http://rainforest-australia.com/rainforest_bats.htm has further information on bats.

http://asgap.org.au/a-gre.html (Australian Native Plants Society) has some more information about the boab (*Adansonia gregorii).*

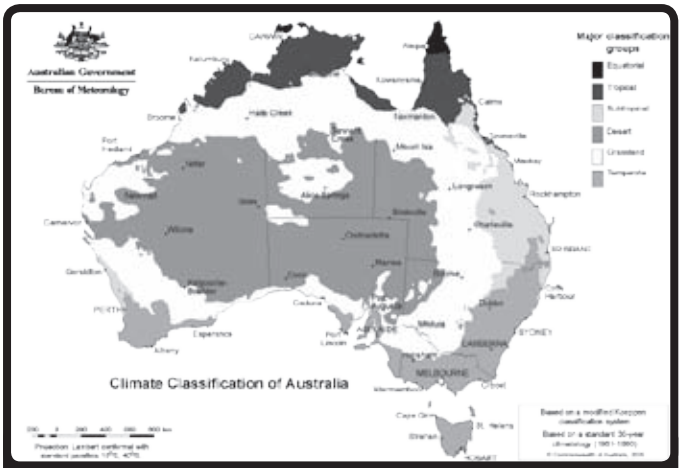
http://www.anbg.gov.au/bryophyte/bryogeography-problems-puzzles.html has some puzzles about bryophytes (mosses and liverworts).

Fossilised Elephant Bird egg. Source: Wikipedia

Patterns

Australia's biodiversity is the result of a combination of factors including climate, soil type and topography.

Climate can be defined in several ways but it is one of the major factors that influence the abundance, distribution and types of species that are found across Australia. The map below shows the climate of each region based on temperature and rainfall.



Climate Classification of Australia (Map). For this full sized map in colour please visit *http:www.bom.gov.au/climate/environ/other/kpn_group.shtml*

SOILS

Australia's vegetation and soil resources are very old, complex and integral components of our biodiversity. The link between plants and the many highly-weathered nutrient-deficient soils is delicately balanced and vitally important for the viability of Australian ecosystems. These ecosystems, including freshwater and marine environments that receive nutrient-poor run-off from the land, are characteristically low in nutrients and have low productivity (low numbers of plants). Low productivity does not however correlate with low biodiversity.

DID YOU KNOW?

Many arid and semi-arid soils have a *biological* crust on their surface. This is a layer mostly comprised of cyanobacteria, green algae, microfungi, mosses, liverworts and lichens. Soil crusts lie dormant during drought and begin growing when the rain comes. They are important for soil fertility, particularly in degraded soils, because micropores in the crust create channels for water to drain into the soil.

SCLEROPHYLLY – A DISTINCTIVE ADAPTATION

The majority of the Australian continent is arid or semi-arid, so it comes as no surprise that many of its flora are specially adapted to survive drought. A distinctive feature of Australian flora is the predominance of sclerophylly – an adaptation where leaves are thick, hardened and resistant to moisture loss and wilting. Sclerophylly is found in 20 plant families in Australia. These include hakeas, grevilleas and eucalypts, as well as acacias and casuarinas. Sclerophylly is also common in some grass families such as grass trees and sedges.

Sclerophyllous species are most commonly found on sandy, infertile soils in low rainfall areas. Areas of sclerophylly in Australia include the Sydney-Blue Mountains region (a World Heritage Area) and the biodiversity hotspot South West Botanical Province of Western Australia.

FIRE

Fire has played an important role in Australian ecology, particularly over the last 40,000 years. Indeed, many Australian plants are well adapted to particular fire regimes. *Banksia coccinea*, for example, begins to senesce (deteriorate and die) after 15 years and requires relatively frequent fires to regenerate. Several other plants, including grass trees and some species of orchids, are known to flower abundantly only after fire.

Some fire-tolerant species produce large quantities of seed that accumulate in the soil or in woody fruit and germinate after fire. In these species, the entire population of growing plants may be killed by the fire and survival is solely from seeds. Such species do not regenerate if the time between successive fires is less than the time required for the plant to reach maturity and produce seed.

Other species are fire-tolerant, using adaptations such as thick insulating bark, numerous buds to allow re-sprouting, and subterranean buds (including large woody rootstock lignotubers), to recover after fire.

EPHEMERALITY

Ephemeral plants are annuals that complete their life cycles in a very short time. The size and life span of ephemeral plants are related to the amount and regularity of water they receive. Ephemeral plants survive as seed in the ground through periods of drought. Heavy rains are the trigger to revive these dormant seeds, which quickly germinate, flower and set seed. The seed store in the soil is then replenished, to survive the next drought. For example, rain on the seeds of ephemeral plants triggers the spectacular WA wildflowers. Around 12 wildflower species have been found throughout WA, with the south-western corner of the state notable for having more species of flowering plants than almost anywhere else in the world.

Epicormic Regeneration. Buds regenerating after fires.

Activities

PRIMARY

Wandering Animals

Animals living in arid and semi-arid environments have adaptations to cope with low water availability. Many large species are nomadic, which allows them to avoid drought by moving between water holes. Examples of nomadic species include the Red Kangaroo (*Macropus rufus*) and the Australian Bustard (*Ardeotis australis*).

If your school is in a rural environment, you may be able to keep count of wandering kangaroos, wallabies and other mammals, but unfortunately this is not possible in an urban environment! However, your students may be able to observe and monitor variations in bird populations as a result of changing seasonal conditions.

Set up a recording grid and ask your students to record the types (species) of birds they see in the school playground. Can they estimate numbers? Are there differences in numbers when it is wet? When it is dry, do the birds disappear? Are there differences in species and numbers at different times of the day? If this chart is kept over a longer period of time, seasonal differences can be detected.

Useful information on keeping records can be found in *Exploring Biodiversity – a resource book of ideas for National Science Week 2001* page 4 at *http://www.asta.edu.au/resources/national_science_week_resource* while page 15 has specific advice on bird watching.

MIDDLE SCHOOL

Media Search

When Lake Eyre filled in 2009 (due to flooding rains in the Cooper, Diamantina and Georgina river systems), for the first time since 2000, birds turned up in their millions for a feeding and breeding frenzy. The links below provide further information:

Nomadic Bird Surveys (Tropical Savannas CRC)
http://savanna.cdu.edu.au/information/info_bird_survey.html

Lake Eyre Basin *www.lakeeyrebasin.org.au/*

Floods bring mass bird breeding frenzy (UNSW Faculty of Science, May 19 2009) *www.science.unsw.edu.au/news/floods-bring-bird-breeding-frenzy/*

Lake Eyre region blossoms after decade-long drought (7:30 Report, May 18 2009)
www.abc.net.au/7.30/content/2009/s2574064.htm

In a similar way, 2010 is shaping up to be an exciting year for Lake Eyre. Display a map of Australia that includes the river systems and creeks that feed Lake Eyre. *http://www.abc.net.au/local/stories/2010/03/23/2853775.htm* has related audio and video clips, as well as photographs of the flooding, movement of water and burgeoning animal numbers.

Ask your students to collect reports about the animals moving to the lake from March 2010 onwards. The puzzles to be solved about the movement of birds are twofold:

1. How do they find out that the lake is filling from hundreds of kilometres away?

2. What do they eat once they get there?

Regeneration after intense fire killed many trees. © Megan Muir 2010

MIDDLE SCHOOL – UPPER SECONDARY

Triggers for Germination of the Seeds of Australian Ephemeral Plants - Investigation

Triggers for germination of Australian native plants can include:

1. Smoke: Studies performed in the fire-prone temperate climate shrublands have shown that plant-derived smoke enhances seed germination in many species.
2. Water: River Red Gum, *Eucalyptus camaldulensis* seeds will only germinate in standing water.
3. Fire or extreme heat: Acacia, Senna and all the pea family have a hard seed coat that is impervious to water and has to be cracked open by fire or extreme heat.

A full list of the treatments that may be required for native seed germination is available at *http://asgap.org.au/seed.html*

To quote from that page: *Not all seed germinates easily. Some seeds have a physical or chemical inhibitor to germination designed so that the seed will only germinate in natural habitats when conditions are favourable. In some cases the inhibitor can be overcome by pre-treatment of the seed before sowing, but with others successful germination has defied all attempts.*

Challenge your students to grow native plants from seed. You can make this challenge a completely open investigation by giving them no more information than that the seeds are from an Australian native plant. For less able students, you can scaffold information and/or steps for planning their investigation.

FURTHER REFERENCES

Fire-related cues break seed dormancy of six legumes of tropical eucalypt savannas in north-eastern Australia *http://www.une.edu.au/ers/staff-profile-doc-folders/peter-clarke/2003-williams-et-al-a-austral-ecology.pdf*

The Untapped Potential of Native Plants *http://www.uq.edu.au/lcafs/documents/Australasian%20Science.pdf*

Australian Native Seed suppliers: A comprehensive list of suppliers around Australia is available at: *http://asgap.org.au/seedsupp.html*

Working Scientifically: Implementing and Assessing Open Investigation Work in Science. A 48-page booklet with scaffolds and detailed information on assisting students with genuine scientific inquiry. Available for download at: *http://www.det.wa.edu.au/education/science/teach/workingscientificallyrevised.pdf*

Biodiversity Hotspots

A biodiversity hotspot is a biogeographic region with a significant reservoir of biodiversity that is threatened with destruction. Fifteen national biodiversity hotspots have been identified within Australia, based on level of endemism (how unique their species are to Australia) and threats to the ecosystem type.

To qualify as a hotspot, a region must meet two strict criteria: it must contain at least 1,500 endemic vascular plant species; and it has to have lost at least 70% of its original habitat.

NAME	IMPORTANT HABITAT	IMPORTANT SPECIES
1. Einasleigh and Desert Uplands (Qld)	High ranges, plateaus, plains and low ranges and artesian springs	Endemic plants, snails, fish, Masked Owl, Julia Creek Dunnart
2. Brigalow North and South (Qld/NSW)	Remnant brigalow scrub and large tracts of eucalypt woodlands	Endemic invertebrates, Bridled Nail-tail Wallaby and only remaining wild Northern Hairy-nosed Wombat population
3. Border Ranges North and South (Qld/NSW)	Subtropical rainforest, wet sclerophyll forest, mountain headlands, rocky outcrops and transition zones	High diversity of birds, macropods and relic Gondwanan species
4. Midlands of Tasmania (Tas)	Wetlands	Endemic plants, mussels, freshwater snails and caddis flies
5. Victorian Volcanic Plain (Vic)	Grasslands, grassy woodlands, wetlands and Ramsar-listed wetlands	65 EPBC-listed threatened species, 173 Vic-listed threatened species, Orange-bellied Parrot, orchids
6. South Australia's South-East/ Victoria's South-West (SA/Vic)	Wetlands including Coorong salt marshes	Orange-bellied Parrot, wetland and coastal seabirds
7. Mt Lofty/Kangaroo Island (SA)	Greatest area of original natural vegetation in South Australia's agricultural zone	Southern Emu-wren, Glossy Black-Cockatoo, Kangaroo Island Dunnart, Southern Brown Bandicoot and Heath Rat
8. Fitzgerald River Ravensthorpe (WA)	Sand plains, Ravensthorpe Ranges and offshore islands	Remnant populations of SW-Australian birds, marine mammals, Cape Barren Goose and Noisy Scrub-bird
9. Busselton Augusta (WA)	Heathlands, shrublands, forests and woodlands, with high rainfall to the south	Endemic plants
10. Central and Eastern Avon Wheatbelt (WA)	Wandoo, York Gum, Salmon Gum and Casuarina woodlands; some proteaceous scrub -heaths	Rich in endemic grevilleas, hakeas, eucalypts, acacias, eriostemons, asteracea and invertebrates
11. Mount Lesueur-Eneabba (WA)	Heaths and scrub-heaths	Reptiles, especially small lizards; dibbler, sea turtles, WA Tammar Wallaby and rare seabirds
12. Geraldton to Shark Bay Sandplains (WA)	Extensive heaths, scrub-heaths and sandplains	Endemic skinks and WA carpet python
13. Carnarvon Basin (WA)	Hummock grasslands, acacia shrublands and woodland; Cape Range caves and sink holes	Sea turtles, seabirds and mammals no longer found on mainland; cave-dwelling animals
14. Hamersley-Pilbara (WA)	Fire-sensitive species and communities. Islands provide refuge and breeding sites for turtles and seabirds	Ghost Bat, Marsupial Mouse, Spectacled Hare-Wallaby, Red Antechinus, Pebble-mound Mouse and endemic reptiles
15. North Kimberley (WA)	Mound springs, swamp rainforests and Airfield Swamp	Gouldian Finch, Golden Bandicoot, Scaly-tailed Possum, Rock Wallaby

CASE STUDY - SOUTHWEST AUSTRALIA ECOREGION

The southwest of WA (also known as the 'Southwest Australia Ecoregion') has such a unique biodiversity that it has been recognised as one of the world's 34 major biodiversity hotspots and the only Australian 'hotspot' to make the list. It has one of the highest levels of endemism in Australia, particularly for flowering plants and amphibians. The region, which has a temperate climate, has been isolated from the rest of Australia for millions of years by the vast inland arid and semi-arid regions. The area has close to 7,000 plant species, which is more than one third of Australia's known flowering plants. About half of these are endemic to the region. This exceptional plant diversity is the reason why the region was added to the global hotspot list. It also has an impressive faunal diversity, with 7 mammal, 13 bird, 34 reptile, 28 frog and 9 fish species endemic to the region. It is likely that endemism is also high amongst invertebrates.

Unfortunately, the Southwest Ecoregion has been severely and adversely impacted by human activity. Its biodiversity is threatened by land clearing (more than 90% of the original native vegetation has been cleared), dryland salinity, altered hydrology, climate change and degradation from grazing by domestic stock, pest species, inappropriate fire regimes and *Phytophthora* dieback (see page 34). The region now has the highest concentration of rare and endangered species in Australia.

Community Action: The Southwest Australia Ecoregion Initiative (SWAEI) is a collaboration between the community, non-governmental organisations, research centres, business and government agencies aiming to conserve and protect the biodiversity of the region. The SWAEI site: *http://swaecoregion.org/about_us.asp* has a hotlink to download a 32-page descriptive booklet about it.

FURTHER READING

Southwest Australia (Biodiversity Hotspots)
www.biodiversityhotspots.org/xp/hotspots/australia/Pages/default.aspx

Southwestern Australia (Gondwana Link)
www.gondwanalink.org/

World Wildlife Fund *http://wwf.org.au/news/workshops-put-spotlight-on-biodiversity-hotspot/*

Activities

LOWER PRIMARY

Introducing food chains

One of the fundamentals of ecology is that no species lives in isolation from other species. There are always interconnections and inter-relationships between even the most solitary of species in an environment. The concept of interdependence can be introduced by considering the needs of a familiar plant or animal.

Choose a local animal with which the children will be familiar and ask them the following questions:

- What does it eat? (What is its prey? Or does it eat plants? Or parts of plants?)
- What animal(s) is/are likely to eat it? (Does it have predators?)
- Where does it shelter? (Does it need another animal for its shelter e.g. is it a flea? Does it rest in a tree like a koala or kookaburra?)
- Does it need a special place to keep its young? (Some birds build nests in trees, whilst others hide nests in long grass. Many animals need hollow logs, holes in trees, or burrows for their babies to rest.)

Once these questions have been discussed, create a diagram that shows the links between the chosen animal and other living things. At this point, the discussion can be extended to consider what happens to the animal if one of the links is broken. Can it survive?

PRIMARY – MIDDLE SCHOOL

Working with food chains

Building on the exercise described above, students can develop a sense of the interdependence of plants and animals living in an environment by identifying all the links that exist between them and, in some instances, the competition that exists for the same resources. The food chains can then be built up and connected to show the resultant food webs.

Resources that will assist this activity:

For marine food chains and food webs: *http://www.environment.gov.au/coasts/discovery/teachers/pubs/food-chains-student.pdf* with the related teacher resource at: *http://www.environment.gov.au/coasts/discovery/teachers/pubs/food-chains-teacher.pdf*

An interactive Australian Grasslands Food Web, African Food Web, Antarctic Food Web and Marine Food Web are at *http://www.gould.edu.au/foodwebs/kids_web.htm* but students' prior knowledge may be need to be assessed first.

Further resource kits on this topic, for both primary and secondary students, can be purchased from *http://www.gould.edu.au/foodwebs/resources.htm*

An educational food chain game: *http://www.wettropics.gov.au/st/rainforest_explorer/Resources/Documents/4to7/FoodChainGame.pdf*

MIDDLE SCHOOL – UPPER SECONDARY

Hotspots v Species

Biologists continue to debate *Is Focusing on 'Hotspots' the Key to Preserving Biodiversity?* The following quotes from *http://www.sciam.com/article.cfm?id=is-focusing-on-hot-spots* can be used to stimulate discussion on the relative value of saving individual threatened species or saving habitats with the broad range of living things which occupy a protected area.

To quote: *In the field of conservation, success stories about saving individual species abound. Bald eagles have recovered from their bout with the pesticide DDT; from fewer than 500 breeding pairs in 1963, the population in the lower 48 (U.S.) states has grown to nearly 10,000 breeding pairs, such that they are no longer listed as threatened under the Endangered Species Act. Gray wolves have returned to Yellowstone National Park, as well as to the Italian and French Alps.*

Further on: *When human ingenuity and resources are trained on a particular species, – usually a charismatic one – it makes a difference but it does not change the global pattern, which is a steady drumbeat of extinction and of the permanent loss of biodiversity that goes with it.*

Finally: *For the past two decades, a leading priority has been to preserve as much biodiversity as possible, and the most prominent strategy has been to focus on 'hotspots '– regions of the world, such as tropical rainforests, that are rich in species and yet losing them fast. The strategy has arguably been successful, yet it has also been controversial.*

1. Ask your students to research any efforts being made in their local communities to:

   • save a particular species

   • protect habitats

   If there are no particular conservation programs in place, they could consider the work of a volunteer community group such as Friends of the Koala *http://www.friendsofthekoala.org/fok/* or the Ningaloo Turtle program *http://www.ningalooturtles.org.au/*

   In each case, the focus of the volunteer group is on a particular species. Ask your students to consider the advantages and disadvantages of such an approach.

2. Is there a listed hotspot in or near your area? If so, ask your students to research the work being done to maintain and preserve it.

   If there is no particular hotspot nearby, they could consider one of the Australian hotspots. This page *http://www.environment.gov.au/biodiversity/hotspots/national-hotspots.html* lists all the hotspots, with hyperlinks to further information on each one.

3. After research and discussion on the relative benefits of each strategy, ask your students to develop an argument essay on the question *Is Focusing on 'Hotspots' the Key to Preserving Biodiversity?*


Bob Brown was the leader of the campaign against the Franklin Dam, director of the Tasmanian Wilderness Society, member of the Tasmanian parliament and the founder of Bush Heritage Australia. He is currently an Australian senator and leader of the Australian Greens Party. While in the Tasmanian parliament he successfully campaigned for a large increase in protected wilderness areas. He has published several books on the Tasmanian environment.
Michael Archer is a vertebrate palaeontologist and mammalogist who recognised the importance of, and worked on, the amazing Riversleigh fauna.
Tim Flannery is one of Australia's leading scientists, named Australian of the Year in 2007. He is a mammalogist, palaeontologist, environmental and global warming activist and science writer.
Bill Humphries is a groundwater scientist who discovered a rich diversity of previously-undescribed stygofaunal species in northwest WA. This identified Australia as a hotspot for stygofauna and is considered one of the most important taxonomic discoveries of the last 15 years. He has also been instrumental in highlighting the importance and fragility of groundwater ecosystems to the pastoral and mining industries.
James Woodford is a popular writer of environment and science books, including The Secret Life of Wombats. As a teenager he investigated wombats by crawling down their burrows and spending time with them. He has inspired a generation of scientists and his wombat research remains relevant today.
The Australian Bi
Knowled
Ian Brooker is the world authority on eucalypt taxonomy. He worked as a botanist for more than 30 years in Australia and overseas, and has discovered and described many new species.
Barry Brook is a scientist and science writer who has received a number of awards for excellence in research, focusing on climate change, computational and statistical modelling, sustainable energy, and human impacts on Earth systems. He currently holds the Sir Hubert Wilkins Chair of Climate Change at the University of Adelaide.
H.B.S Womersley has devoted a lifetime to coastal algae research, especially on the fascinating and complex red algae.
Terry Hughes is one of the world's leading coral reef scientists, with broad research interests in ecology, marine biology and the social-ecological dynamics of coral reefs.
Barbara Triggs is an Australian authority on the identification of mammal scats, tracks, hair and other remains. Her work is vital to research carried out by National Parks and state forestry bodies. She is the author of several natural history books.
Joan and Eileen Bradley are sisters who pioneered the Bradley Method of bush regeneration in the 1960s. This method encourages minimal soil disturbance and natural re-establishment of native plants from the soil seed bank. The Bradley Method is still widely practised today.
Gary Poore has worked on many clades of crustaceans, including coordinating international efforts. He also has explored the great diversity in benthos of the continental shelf.
Pat Mather AO, publishing as Patricia Kott, has spent her working life devoted to ascidian (sea squirt) research and has described 500 of the 700 known species in Australia. Sea squirts are significant as they are one of the main filter feeder species in marine communities and are extremely important on coral reefs.
Rob Kooyman, who has completed extensive surveys and exploration of Australian rainforests, initially worked with *Len Webb*. He was subsequently a forest ecologist with State Forests NSW, and then a consultant to NSW NPWS. In 2000, he discovered *Eidothea hardeniana* (the Nightcap Oak), a basal genus that separated from other Proteaceae probably ca 90 mya), and he continues to work on the genetics of several endangered species.
Leonard Webb completed an extensive survey of Australian rainforests which established that they were ancient and indigenous, not a spill-over from Indo-Malaysian forests.

odiversity ge Tree

20th and 21st Century contributors

Craig Moritz and Steve Williams, under the auspices of the Wet Tropics CRC, used genetic methods on a range of taxa to elucidate the timing and processes involved in speciation and how they relate to fragmentation of the rainforests during the Pleistocene period in Australia.

David Noble is a NSW National Parks and Wildlife Officer and keen bushwalker who discovered the Wollemi Pine (*Wollemia nobilis*) in 1994 in a rainforest gorge in Wollemi National Park. He came across a grove of trees that he did not recognise and called in the Senior Naturalist for the park, who realised that they were a completely new species. The Wollemi Pine is a Gondwanan relic species and one of the world's oldest and rarest trees.

Abigal Allwood is a Melbourne-born geologist who received international recognition for her PhD research on fossilised stromatolites in the Pilbara region of WA. She dated them at 3.43 billion years old, which makes them the oldest evidence of life on Earth. Her research made the front cover of the prestigious scientific journal Nature in 2006, and COSMOS magazine listed her as one of Australia's top 10 scientific minds.

Richard Kingsford is an internationally recognised expert on the ecology of migratory birds, rivers and wetland systems and river regulation in the arid and semi-arid zones of Australia. He has undertaken extensive research on Cooper Creek (Lake Eyre Basin) and the Murray Darling Basin, and was a member of the consultative committee for the Water Initiative, which involves buying water back from irrigators.

Katherine Belov is a geneticist whose work on the population genetics of Tasmanian devils has proved essential to the conservation of the species. She discovered that low genetic diversity within the devil population is the reason why Devil Facial Tumour Disease (DFTD) is wiping them out.

Barbara Main has contributed to science with unique, long-term studies of the life history/demography of several marked field populations of trapdoor spiders, which include two individuals now over 31 years old. The maximum age spiders reach is still not known, but this extraordinary life span has significant implications for conservation and management in small reserves and remnant bushland.

Maarten Stapper is an agricultural scientist and passionate advocate of biological farming. His extensive experience in quantifying production in dry-land and irrigation wheat paddocks in south-eastern Australia led him to recognise the importance of soil biology and soil health for agro-ecosystem function. Maarten appeared on the ABC's *Australian Story* in 2009.

Bob Pressey is involved in conservation planning and his research aims to build practical planning tools and software that enable local communities to anticipate both movement in native species and take a precautionary approach to the emergence of new risks. His tools thus guide decisions about conservation. Behind these tools there is the sophisticated and complex science of understanding and modelling of changes in natural and human systems, and predicting how they affect one another.

Andrew Beattie's main research interests are the interactions between arthropods and microorganisms, the role of microbes in the evolution of sociality, invertebrates as biological resources, the relationships between ecology, evolutionary biology and bioprospecting and biodiversity conservation.

Robert Hill is best known for his research on the fossil history of the southern beech, *Nothofagus*, and the southern conifers. His research on the fossil history of *Nothofagus* has been critical in refining our understanding of its evolution and has led to a major revision in our understanding of the biogeography of this critical southern genus. His botanical research has made significant contributions to the areas of palaeobotany, plant systematics, plant ecophysiology and the application of research from these areas to interpreting changes that have occurred to the Australian flora through evolutionary time.

Geoffrey Sharman's research was in the area of mammalian evolutionary biology and his work included a description of the multiple sex chromosomes of the Black-Tailed Wallaby and the Potoroo. He described the phenomenon of dormant blastocysts in the Quokka and was elected to the Australian Academy of Science for his discovery of embryonic diapause in macropods. He also worked on the taxonomy of rock wallabies, which is the most diverse clade of marsupials.

Noel Tait recognised and described the huge diversification in Onychophora (Velvet worms), a very important group of invertebrates with an exotic natural history.

Humans and Australian Biodiversity

Even though humans have changed the environment and altered ecosystems in many parts of Australia, it is amazing how much variety still exists within and among environments that are densely populated and heavily used by people.

THE URBAN ENVIRONMENT provides habitats for many native species.

Mammals: Many urban dwellers have had either a Brushtailed Possum (*Trichosurus vulpecula*) or Ringtail Possum (*Pseudocheirus peregrinus*) in their roof or backyard. These two species have adapted well to life in the city and are thriving throughout their range.

Fruit bat colonies set up camp in trees regardless of nearby human inhabitants. Microbats are also known to utilise disused mine shafts and other artificial structures as roosts.

Reptiles: Representatives of each lizard family (geckos, legless lizards, dragons, goannas and skinks) are found in all capital cities in Australia, except Hobart, which only has dragons and skinks. People living in a tropical or subtropical region may have a larger reptile in the form of a python living in the roof. Darwin residents even need to be wary of saltwater crocodiles (*Crocodylus porosus*), which occasionally turn up in the stormwater drains.

Birds: Birds that do well in cities tend to be those that prefer open-space habitats, such as Masked Lapwings (*Vanellus miles*), Noisy Miners (*Manorina melanocephala*), Kookaburras (*Dacelo novaeguineae*) and Parrots (e.g. Lorikeets).

Amphibians: Frogs are usually sensitive to environmental disturbance, but this has not stopped Green Tree frogs from inhabiting sinks, toilets and drain pipes across NSW, Qld, the NT and northern WA.

Urban bushland: Reserves can be home to a surprisingly rich diversity of native plant species. Blue Gum High Forest, a plant community listed as critically endangered under the Environment Protection and Biodiversity Conservation (EPBC) Act 1999, now exists ONLY as scattered remnants in bushland reserves throughout northern Sydney.

IMPROVING THE BIODIVERSITY VALUES OF OUR CITIES

Urbanites are becoming increasingly aware of the need to improve the biodiversity values of their city. In a fragmented city landscape, small pockets of bushland and even individual trees can provide critical habitat for the local wildlife. In some parts of northern NSW koalas and humans live side by side in bushy urban areas. Researchers have shown that in some cases, the home range of a koala can be a single tree, making the preservation of every tree important!

Native gardening has increased in recent years out of recognition of the need to provide habitat for native species in the urban environment, as well as to conserve water. Native birds quickly return once a home garden has been planted with local native species.

Regeneration and maintenance of urban bushland reserves is also now common practice and most cities have volunteer Bushcare groups. *Habitat connectivity* (the number of links between patches of native vegetation) is an important issue that town planners must now consider. Habitat connectivity allows adjacent populations to interbreed, maintaining genetic diversity. Scientists and councils have tried to improve habitat connectivity for small mammals in developed environments by constructing aerial bridges over, and tunnels under, major roads and pipelines.

Many of our native arboreal fauna are dependent on tree hollows for nesting. In areas where hollow-bearing trees have been removed, artificial nest or roost boxes are considered important habitat for birds and arboreal mammals.

AGRICULTURAL ENVIRONMENTS

With more than 60% of the Australian continent being used for agriculture, it is important to consider the biodiversity values of agricultural systems. Much of this land has been converted from forest or woodland to pasture, which has benefited some native species, but severely and permanently disadvantaged many others.

Some species utilise our crops as food sources, particularly if their natural food sources have been disrupted by land clearing etc., e.g. Sulphur-crested Cockatoos (*Cacatua galerita*) feed on grain crops, flying foxes on fruit orchards and dingoes (*Canis lupus dingo*) on livestock.

Predatory birds (e.g. hawks, kites, eagles) can be considered to have benefited from land clearing, as prey species are no longer protected by vegetation, although the raptors may also have lost nesting and roosting trees, and roads provide them with a constant (if hazardous) supply of food in the form of road kill. A variety of bird species now uses power poles as survey platforms in areas where the native vegetation has been cleared.

A native gecko (*Gehyra australis*) inside dwelling, Jabiru NT.

Activities

Reference for further activities on biodiversity in the urban environment

Exploring Biodiversity – a resource book of ideas for National Science Week 2001 pages 13-32 describes many different activities which can be used to demonstrate biodiversity in the urban environment. This booklet can be downloaded as a pdf from *www.asta.edu.au/resources/national_science_week_resource*

LOWER PRIMARY

What's in your backyard?

All ages could do a variation on this activity, which is written with Lower Primary students in mind.

You will need a clear plastic cup, small plastic spoon and a small clear container with a lid for each student (or each group). A roll of masking tape will also be needed.

Go on a treasure hunt outside the classroom and in the school grounds. The students are to find and collect ANYTHING they feel is interesting and that will fit into the cup. Living animals such as small ants can be 'caught' with the spoon and stored in the lidded container.

Back in the classroom have children sort their treasures into plant-related, animal-related and inanimate (never been alive) groups, justifying their choices. This can be done as a whole class within masking tape shapes on the classroom floor, or into separate tote trays.

The next step is to sort again within each of the categories. For example: plant-related can be separated into leaves, flowers, seeds, bark etc. Further classification can then take place with different leaves being identified. This is the beginning of recognising the diversity of various features of plants in the school and broader environment.

PRIMARY – MIDDLE SCHOOL

Start with an awareness-raising exercise by asking your students to build up a list of all the native mammals, birds and reptiles they know about in their area. It often produces a surprisingly long list and draws their attention to what is out there.

Earth Alive is a Sydney-based, 9 to 11-week Science and Technology program that aims to develop knowledge, understanding and respect for ecosystems and biodiversity. On pp. 19-20 the Bio Investigator has directions for searching the ground and trees for invertebrates, and ideas for data analysis. The 60-page booklet can be downloaded from *http://www.fieldofmar-e.schools.nsw.edu.au/downloads/assets/EarthAlive%20Book%202009.pdf* (NB this file is 98MB)

Biodiversity Up Close. This booklet is a 73-page downloadable pdf (3.2 MB). Pages 13-24 have an excellent cross-disciplinary activity that will require online access to Google Earth and various websites. Download from: *http://www.rbg.vic.gov.au/__data/assets/pdf_file/0003/6717/Biodiversity_Up_Close_School_Grounds.pdf*

The Green and Golden Bell Frog (*Litoria aurea*) is a ground-dwelling tree frog native to eastern Australia. Unlike most frog species it is often active during the day. Image: iStock

UPPER SECONDARY

Industrial sites – the story of the Green and Golden Bell Frog

One of the most famous examples of a native species inhabiting an industrial site is the Green and Golden Bell Frog (*Litoria aurea*), which is listed as vulnerable under the EPBC Act. The species is now restricted to several isolated populations in NSW, the ACT and Vic.

Frogs are usually very sensitive to environmental change (e.g. water salinity, turbidity, oxygenation and pollution). However, the Green and Golden Bell Frog has made its home in some highly-disturbed sites such as disused industrial areas, brick pits and quarries.

The species was even found in the old Homebush Bay brick pit when the area was being developed for the 2000 Sydney Olympics. At the time, Homebush Bay was considered one of the most polluted sites in the southern hemisphere due to the dumping of industrial waste straight into the wetlands for many years. The site was rehabilitated as part of the Olympic site development, but remains highly contaminated. However, the population of frogs at Homebush Bay has survived and now consists of about 3,000 individuals. It is the largest-known population of this species of frog. Unlike most Australian frogs, they seem to be able to tolerate saline water and heavy metal pollution.

Green and Golden Bell Frogs living on industrial sites present a challenge for wildlife managers. Do they preserve the contaminated site, since the frogs seem to love it so much, or attempt to rehabilitate both the site and the frogs?

Ask your students to brainstorm the problems of polluted industrial sites with respect to human health and safety. What should wildlife managers do about such situations? Sacrifice human health for the frogs? What could a compromise solution be? This can be expanded into an excellent problem based learning set of lessons.

Problem based learning introduction at h*ttp://www.smate.wwu.edu/teched/pbl.html* with further links.

Green and Golden Bell Frog (EPBC) *www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1870*

Frogfacts No. 5: Green and Golden Bell Frogs (Frog and Tadpole Study Group) *www.fats.org.au/Publications_files/FF5%20of%20April%2006.pdf*

Indigenous Australian Knowledge of Biodiversity

INDIGENOUS LAND OWNERSHIP

About 12% (91 million hectares) of the Australian landmass is under formal Indigenous ownership. Most of this area is in the arid zones and (to some extent) the tropical north of the NT (48.3 million hectares), WA (23.3 million hectares) and SA (16.9 million hectares).

Within Indigenous lands, areas known as Indigenous Protected Areas (IPA) have been created. An IPA is an 'area of Indigenous-owned land or sea where traditional owners have entered into an agreement with the Australian Government to promote biodiversity and cultural resource conservation'. There are currently 36 declared and 40 proposed IPAs in Australia, covering approximately 20 million hectares. IPAs comprise over 23% of the National Reserve System (see page 42). Other land uses within Indigenous lands include pastoral activities and mining. *http://www.environment.gov.au/indigenous/ipa/background.html* has background information and links about IPAs.

A map is available at *http://www.environment.gov.au/parks/nrs/about/ownership.html*

INDIGENOUS BIODIVERSITY KNOWLEDGE

Indigenous knowledge is a vast and intricate knowledge of the natural environment aquired over tens of thousands of years. It includes awareness of such things as the uses of flora and fauna for food and medicine, seasons, climate, water and fire management. It is important that this knowledge is preserved and used alongside western science in biodiversity preservation.

FIRE MANAGEMENT – A CASE STUDY

Many of the plants and animals across Northern Australia are adapted to survive some fires. With traditional practices, small patches of grassland were burned throughout the year as Indigenous people moved through the country. In the Top End and northern Kimberley, many fires were lit in the early to mid dry season. These smaller and less intense fires of traditional practices maintain more diverse habitats than large, late dry season fires.

Since European settlement, much of this fire management has ceased. The result has been a change in fire patterns, with a significant increase in large destructive fires that result in habitat and species loss.

Traditional fire management has been resumed in Lakefield National Park, in Far North Queensland, as the Kuku-Thaypan Elders re-introduce therapeutic burning regimes to their country, whilst documenting the traditional knowledge that underpins such fire practices. The Indigenous philosophy of fire management attempts to avoid hot fires and focuses on small, cool, controlled burns at specific times, also taking into consideration ceremony and rock art areas.

Peta Standley, a James Cook University doctoral student, has worked with the Elders to quantify any vegetation and fauna changes as a result of the burns. Remote sensing imagery, fieldwork and informal interviews are the basis of data gathering before, during, and after the fires.

In this way, western science and traditional knowledge are combined under the direction of traditional Elders. Historical and contemporary knowledge about fire and vegetation is also gathered to support findings. The project aims to show how traditional burning practices can help in reversing weed infestation and biodiversity decline in this tropical savanna area of Cape York Peninsula.

"At the time European people arrived in Cape York, species of flora and fauna relied upon an established Indigenous fire regime," says Peta Standley. "This means that species such as the Golden-Shouldered Parrot continue to need similar regimes to cater for all their survival needs. The species loss we are now seeing in Cape York is linked to changed fire regimes and land use patterns."

The information above has been extracted from: *http://www.nrm.gov.au/publications/factsheets/pubs/bio-indigenous.pdf http://www.tkrp.com.au/* This website has more details of this research project.

http://savanna.org.au/all/fire.html has further information on the history of fire across northern Australia. The drop-down menu on the left-hand side of the page has a series of links to related resources. For example, *http://savanna.org.au/all/fire_impacts.html* discusses the impact of fire on biodiversity and *http://savanna.org.au/all/fire_indigenous.htm* outlines the relationship between fire and Indigenous culture.

http://www.environment.gov.au/parks/kakadu/management/programs/fire.html describes the fire management plan for Kakadu and includes further links to more information on the management plans.

ACTIVITY – USING INDIGENOUS KNOWLEDGE

Until 1993 genetic resources were commonly considered the 'common heritage of mankind' and their utilisation for new products was largely undertaken without regard to the communities from which the source material was drawn. Thus, major discoveries based on natural resources (sometimes involving the use of Traditional Indigenous Knowledge) resulted in no benefits flowing back to the country or community providing that material. From *http://www.anbg.gov.au/anbg/NCA/understanding-nca.html*

The Bundjalung people of eastern Australia have known about the healing and disinfecting properties of tea tree oil for thousands of years. Trace the knowledge of this oil through to its use today. How much benefit have the Bundjalung people received for sharing their knowledge? *http://www.teatree.org.au/teatree_about.php*

If you have access to a local Indigenous community, perhaps they will share some knowledge with your students. For example, what bush tucker is available in your area? Could the plants that provide this bush tucker be grown in the school garden or in home gardens? How can they be turned into a tasty meal? *http://www.teachers.ash.org.au/bushtucker/index.html* and *http://bushfood.net/bushtucker_full.htm* are useful sites.

Threats to Biodiversity in Australia

CHAPTER 3

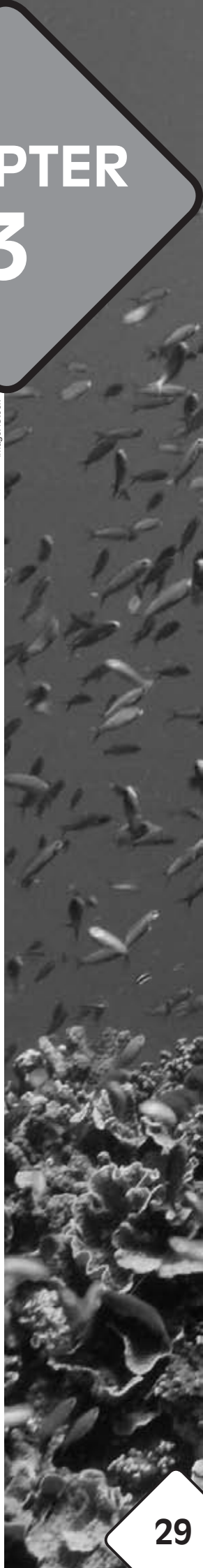


Image: iStock

The world is in the middle of what many scientists are calling the 'Sixth Mass Extinction'. The first five mass extinctions occurred in the geological past and were a result of global climate change (either cooling or heating). The sixth mass extinction is different in that it appears to have been caused by humans.

The Sixth Extinction can be divided into two discrete phases:

Phase One began when the first modern humans began to disperse to different parts of the world about 100,000 years ago. For example, there are indications that they over-hunted game species which had never before been in contact with humans.

Phase Two began about 10,000 years ago when humans turned to agriculture. To quote palaeontologist Dr. Niles Eldredge from his article at *www.actionbioscience.org/newfrontiers/eldredge2.html* on the Sixth Extinction:
"Agriculture represents the single most profound ecological change in the entire 3.5 billion-year history of life. With its invention:

- *humans did not have to interact with other species for survival, and so could manipulate other species for their own use,*
- *humans did not have to adhere to the ecosystem's carrying capacity, and so could overpopulate."*

Globally, humans have caused the extinction of a total of 86 flora and 723 fauna (including 76 mammal, 133 bird, 21 reptile, 37 frog, 7 crustacean and 60 insect species). A further 21% of mammals, 12% of birds, 5% of reptiles, 29% of amphibians and 4% of fish in the world are threatened with extinction.

Australia is in the midst of a biodiversity crisis. Since European occupation it seems that 48 flora, 27 mammal, 23 bird, 4 frog and 1 earthworm species have become extinct (source: EPBC Act Lists). A further 6% of vascular plants, 20% of mammals, 6% of birds, 5% of reptiles, 14% of amphibians, 1% of fish, 32 invertebrates, 2 algae and one bryophyte in Australia are threatened with extinction. Australia's threatened reptiles account for about 11% of the world total of threatened reptiles. These species extinctions and population declines are due to a combination of factors, which will be outlined in the following pages.

The International Union for Conservation of Nature (ICUN) Red List of Threatened Species is a global list of those species most in need of conservation. Some Australian species listed as endangered and critically endangered on the ICUN Red List include the Leatherback Turtle (*Dermochelys coriacea*), Mitchell's Rainforest Snail (*Thersites mitchellae*), Mountain Mistfrog (*Litoria nyakalensis*), Numbat (*Myrmecobius fasciatus*), Orange-bellied Parrot (*Neophema chrysogaster*) and Speartooth Shark (*Glyphis glyphis*).

Leatherback turtle. Source: Wikipedia

Impact of Habitat Loss

Habitat degradation is the loss in ecological quality of a habitat due to one or more factors, usually associated with human activity. Some species have very specific habitat requirements, and once the habitat becomes degraded it may no longer satisfy that species' habitat requirements.

HOW IS LAND IN AUSTRALIA USED?

Different types of land use include urban, agricultural, mining, forestry and conservation. The table below lists the types of land use in Australia (in 2001/02) and the amount of land devoted to each type. The most extensive land use type in Australia is livestock grazing in arid and semi-arid regions, covering 55% (4,194,721 km2) of the continent.

LAND USE	AREA (km^2)	% OF TOTAL
Nature conservation	529,380	6.89%
Other protected areas (e.g. Indigenous use)	985,749	12.82%
Minimal use (reserved, vacant, Crown land)	1,169,748	15.21%
Grazing natural vegetation	4,194,721	54.56%
Production forestry	133,064	1.73%
Plantation forestry	16,879	0.22%
Grazing modified pastures	229,349	2.98%
Dryland cropping	235,931	3.07%
Dryland horticulture	1,165	0.02%
Irrigated pastures and cropping	25,992	0.34%
Irrigated horticulture	4,543	0.06%
Rural residential	9,442	0.12%
Urban intensive uses	14,031	0.18%
Mining	1,366	0.02%
Water	134,869	1.75%
No data	2,274	0.03%
Total	**7,688,503**	**100.00**

Source: 2001/02 Land Use of Australia, Version 3, Bureau of Rural Sciences
http://adl.brs.gov.au/mapserv/landuse/pdf_files/Web_LandUseataGlance.pdf

There are many human activities that cause ecosystem degradation. The table below lists various types of land use that cause degradation for a range of habitats.

Australia has the fifth-highest rate of land clearing in the world and the highest rate for developed countries. Australians clear about half a million hectares of native vegetation per year and approximately 85% of this occurs in Queensland. Tasmania has the highest rate of clearing proportional to the state's total area. All states in Australia now have legislation to regulate land clearing and clearing activities can be monitored using satellite technology.

Land clearing and certain types of land use result in land degradation and habitat loss. Types of land degradation include loss of (or damage to) native vegetation; weed and feral animal incursions; soil degradation (e.g. increased salinity and structural breakdown); erosion; changed fire regimes; pollution and changes in ground and surface water hydrology.

URBAN SPRAWL

The built environment (encompassing urban, peri-urban and open cut mines) occupies only about 0.3% of Australia. It is however Australia's most intensive type of land use. Urban sprawl is the outwards expansion of a city and its suburbs. About 70% of Australia's population currently lives in its 10 largest cities. The number of people living in cities is predicted to increase and urban areas must therefore expand. Habitats in the urban environment are generally degraded and highly fragmented. Genetic and species diversity within these remnant patches is much less than would previously have existed.

AQUATIC ENVIRONMENTS – MARINE AND FRESHWATER

Freshwater and marine habitats are degraded by siltation, nutrification, pollution, aquaculture and unsustainable fishing practices such as trawling.

In particular, the nutrient-poor nature of Australian soils means that phosphorus-rich fertilisers are often used excessively and through run-off, cause over-enrichment of lakes and rivers with nutrients that result in excessive growth of algae and other plants.

Increased levels, particularly of nitrogen and phosphorus, in freshwater ecosystems lead to algal blooms and excessive growth of *macrophytes* (vascular, rooted plants that grow in streams). Due to low flows and high nutrient levels, algal blooms are now common throughout much of the Murray-Darling Basin.

Seagrasses, found in shoreline brackish or marine waters in temperate and tropical regions are particularly sensitive to disturbance. They are productive environments that provide habitat for a variety of species, including the dugong (*Dugong dugon*).

HABITAT TYPE	HUMAN USES
Grasslands and shrub lands	Rangeland grazing, agriculture, urban development
Forests and woodlands	Agriculture, forestry, clearing for urban development
Mangrove-salt marsh communities	Fishing, recreation, sewage and waste water discharge, waste disposal, reclamation for coastal development
Beaches	Sand mining, urban development
Coral reefs	Fishing, recreation, tourism, coral extraction
Freshwater wetlands	Fishing, recreation, sewage, waste water discharge, reclamation
Freshwater lakes and rivers	Fishing, recreation,
Coastal marine systems	Fishing, recreation, sewage, waste water discharge
Groundwater aquifers	Groundwater extraction
All	Mining, conservation

Activities

The activities on this page are designed to develop the concept of habitats, so that students will see the benefits of preserving habitats for Australian flora and fauna.

LOWER PRIMARY

Introducing the concept of habitats

Living or Not Blake Education (Level 3 reader) can be used to introduce the concept of living and non-living things.

Continue by reading a book about living things, such as *What can Fly?* (Brenda Parkes, Inquizitive program, Pearson Education Australia.) This little book shows a range of flying animals with and without backbones. Ask your students to think about:

1. Why are they flying? How are they flying?
2. Where do they go when they are not flying?

This can lead to a discussion of some of the characteristics of living things – they need food, water and shelter. The word 'habitat' can be used to describe the place where food, water and shelter exist for flying animals i.e. where the animal lives.

Similarly, *The Pond* (Brenda Parkes, Inquizitive program, Pearson Education Australia.) identifies some of the organisms that live in a pond. The pond is the habitat of these plants and animals.

1. What does the pond provide for the plants and animals?
2. What might happen to the plants and animals if the pond disappeared?

A habitat quiz

http://www.environment.nsw.gov.au/edresources/MatchTheAnimalsToTheirHabitats.htm has line drawings of several animals and four photographs of Australian habitats. Use this online resource to discuss the very different habitats that animals in Australia occupy.

PRIMARY

Animals and their habitats

A habitat is defined as the specific place or natural conditions in which a plant or animal lives.

Part 1. Exploring the schoolyard habitat: Conduct a survey to find out what animals live in or move through the schoolyard. Make sure that students include the 'bugs' they find.

Draw up a table with two columns. In the first column, list each of the animals found. In the second column, write down exactly where the animal lives.

Students can then be led through a discussion of the places where animals live to understand that many different animals can share the same environment, as they occupy different spaces and places in that environment or habitat.

Part 2. Beyond the schoolyard habitat: Did your students observe any large animals? For example, they may have seen birds flying in and out of the schoolyard. The next discussion can thus include consideration of what places the birds might use for shelter and nesting. What habitats exist in your local area for native animals such as birds? How much disruption is being or has been caused by urban development? How many homes have bird-friendly trees?

Exploring Biodiversity – a resource book of ideas for National Science Week 2001 page 29 has an activity that identifies animal habitats. *www.asta.edu.au/resources/national_science_week_resource*

MIDDLE SCHOOL

Exploring Biodiversity – a resource book of ideas for National Science Week 2001 page 31 has an activity that models habitat fragmentation. On the same page is an interesting research activity to identify changes in local ecosystems over time. *www.asta.edu.au/resources/national_science_week_resource*

An animal and its habitat

Ask each group of students to select one of the animals listed below and use the questions suggested to help prepare a presentation about that animal.

The questions to be answered by each group could include:

1. Describe the animal and its habitat. Include information about its distribution (where is it found?) and its abundance (how many individuals of the species exist?)
2. What current information is available about its species status? Is it threatened? Are numbers stable? Are numbers increasing?
3. What are the specific needs of this animal in terms of:
   a. nutrition?
   b. shelter?
   c. breeding grounds?
4. Are the habitats of this animal secure and unaffected by human land usage? If not, what measures are being taken to protect the habitats and their communities of plants and animals?

The animals could include:

1. Dugong
   http://www.kidcyber.com.au/topics/Dugong.htm for less able readers
   http://sydneyaquarium.myfun.com.au/upload/Document/CLA030_17_1_1.pdf for average readers
   http://www.uq.edu.au/marinevertebrate/dugongs for more in-depth information, including details of current research being undertaken on this species.
2. Platypus
   http://www.kidcyber.com.au/topics/platypus2.htm for less able readers
   http://www.australianfauna.com/platypus.php for average readers
   http://www.dpiw.tas.gov.au/inter.nsf/WebPages/BHAN-53573T?open contains detailed information for more able students.
3. Rock Wallaby
   This topic can be state-based (except Tasmania) as there are some rare or threatened species in each Australian state. Alternatively, for an Australia-wide perspective, ask each group of students to research one of the wallaby species listed below.
   A starting point for all students could be: *http://rainforest-australia.com/Rock_wallaby.htm*
   NSW and Victoria: the Brush-tailed Rock Wallaby *http://www.rockwallaby.org.au/* and *http://www.vicrockwallaby.com/wallaby.htm*
   WA and NT: the Black-footed Rock Wallaby *http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66650* and *http://www.nt.gov.au/nreta/wildlife/animals/threatened/pdf/mammals/blackfooted_rockwallaby_nt.pdf*
   Qld, NSW and SA: the Yellow-footed Rock Wallaby *http://www.zooaquarium.org.au/Yellow-footed-Rock-wallaby/default.aspx*

Impact of Invasive Species

Invasive species cause damage to environmental, agricultural or social resources. They may also be referred to as a pest, feral, exotic or introduced species. An invasive species can be a disease, fungus, parasite, invertebrate, marine pest, feral animal or weed. Invasive species in Australia usually come from other countries, but may include misplaced Australian species.

WEEDS

A weed is **any** plant growing in a place where it is not wanted. It can be a grass, herb, shrub, tree, vine or aquatic plant.

Weeds generally occur in environments that have been disturbed by native vegetation removal, soil excavation, pollution, feral animals, or in the aquatic environment, nutrification or hydrological change. Weeds are generally classified as environmental or agricultural weeds, depending on whether they impact on natural or agricultural systems. There are very many different types of weeds in Australia, with each state and local area identifying particular species as weeds.

Some examples include blackberry (*Rubus fruticosus*), which plagues the southern and eastern coastal regions due to its preference for temperate climates with high rainfall. Parkinsonia *(Parkinsonia aculeata*), on the other hand, is able to tolerate heat and drought and is found throughout the sub-humid, semi-arid and arid environments of north Australia.

FERAL ANIMALS

Australia's most problematic feral animals are the camel, cane toad, cat, donkey, red fox, rabbit, goat, horse, pig and water buffalo. Details of the introduction and distribution of each of these are provided in the table below.

PEST	INTRODUCED	PURPOSE OF INTRODUCTION	PRESENT DISTRIBUTION
Camel	1840s	Outback transport	Central Australia
Cane toad	1930s	Failed biological control for cane beetle	Northern NSW, Qld, Top End and Kimberley
Cat	Uncertain	Introduced intentionally or accidentally, perhaps even before 1788 settlement	Throughout Australia
Donkey	1860s	Haulage teams in northern Australia	Central Australia, WA and NT
Red fox	1870s	Game for hunting	Most of Australia
Rabbit	1788	Game for hunting	Throughout Australia except the north of WA, Qld and NT
Goat	1788	Meat, fibre and skins	Throughout Australia
Horse	1788	Transport	Qld, NT, WA, alpine and sub-alpine areas of NSW
Pig	1788	Meat	NSW, Qld, Top End
Buffalo	1920-40s	Meat for north Australian settlements	North Qld, Top End and Kimberley

THE JUDAS DONKEY

The Judas method of feral animal control works for animals with social behaviour patterns. It involves putting a radio collar on an animal and then releasing it into an area known to contain a feral population. The collared individual eventually joins the feral group, providing controllers with information about the group's location. The feral herd is culled, but the Judas animal is left alive to seek out a new herd. The process is then repeated with the new herd. In Australia, the Judas method has been particularly successful for feral donkeys. Donkeys were brought into northern Australia for use as pack animals in the 1860s because poisonous plants prevented the use of horses. Donkeys eat a wider range of vegetation and are able to graze further away from water. They thrive in parts of the NT and in the harsh escarpment country of the Kimberley and Pilbara (northern WA). In 1994, the WA government commenced the 'Judas Project', which aimed to control donkey numbers in the Kimberley region. More than 270 radio-collared animals were released into an area covering approximately 150,000km^2. The project has now reduced the feral population by half a million animals. The Judas method has also been used for goats and pigs in Australia.

FERAL BEES

Small pest species are capable of causing large environmental problems. The European Honey Bee (*Apis mellifera*) was introduced by the early settlers to help pollinate crops and now occurs throughout much of Australia. The Honey Bee competes with native bird species for tree hollows and can kill birds outright during swarming. In WA it threatens the rare Red-tailed Black Cockatoo, which uses tree hollows for long-term nesting sites.

CAN THERE EVER BE TOO MANY KOALAS?

Native species are sometimes considered to be pests of natural, agricultural or urban environments.

Koalas (*Phascolarctos cinereus*) are a threatened species in Qld and NSW, but in parts of SA and VIC, the species continues to flourish in the wild. However, koalas were introduced to Kangaroo Island (off the coast from Adelaide) in the 1920s as a way to help preserve the species, which was on its way to extinction in SA. Only 18 breeding individuals were introduced to the island, but by 2001 the population was estimated to be 27,000! Managers feared for the island's eucalypt forests, which were becoming defoliated due to over-browsing by koalas.

The Koala Management Program was initiated in 1997 and since then around 6,100 koalas have been sterilised, and 30% of those have been relocated to areas of the koalas' former home range in south-eastern South Australia. This translocation of sterilised koalas achieves two outcomes: it reduces pressure on the habitat trees of Kangaroo Island and prevents over-population in the mainland habitat.

Activities

PRIMARY

Feral Animals and Weeds

NSW National Parks and Wildlife has a page of information, a simple activity to download and further information on management of weeds and feral animals at *http://www.environment.nsw.gov.au/edresources/FeralAnimalsAndWeeds.htm*

The *Discover Nature on Eyre Peninsula* resource has step-by-step instructions on a number of suitable activities for primary students. While these instructions relate specifically to the Eyre Peninsula, the activities are readily translatable to other regions of Australia. The 13-page booklet is available for download at: *http://www.environment.sa.gov.au/biodiversity/west_bcp/pdfs/discover_nature_topic5.pdf*

PRIMARY – MIDDLE SCHOOL

Weed watchers. Using the Bradley Method

Australia's worst weeds are known as WoNS (Weeds of National Significance) species. The WoNS weeds are: alligator weed, athel pine, bitou bush, bridal creeper, blackberry, cabomba, Chilean needle grass, gorse, hymenachne, lantana, mesquite, mimosa, Parkinsonia, parthenium weed, pond apple, prickly acacia, rubber vine, salvinia, serrated tussock and willow.

Your students could become vigilantes in the fight against weeds. The story of the Bradley sisters (see centre spread), their initial efforts to weed the bush and their innovative approach to bush regeneration can be used to motivate students, and remind them, that every little effort helps. *http://asgap.org.au/APOL4/dec96-5.html* has the details. The important concept used by the Bradley sisters was to allow local native species to regenerate naturally, rather than plant weeded areas with introduced native or exotic species.

Use both state government and local council websites to find out which plants are declared to be noxious weeds in your area. What are the regulations concerning noxious weeds in your area? It is likely that you and your students will already be familiar with one or more of these species. It will be important that students understand the risks and precautions needed when removing weeds, such as wearing gloves and protective clothing. Perhaps your school yard is a good place to start with a slow but steady removal of weeds. Could students begin by clearing one weed – noxious or otherwise?

Cootamundra Wattle. Image: Wikipedia

People watching over invasive species – Careers in Science

There are many scientists and technicians across Australia whose roles involve developing programs to deal with invasive species and/or protect the Australian environment from further invasions. Ask your students to investigate one of the following occupations and identify the skills and knowledge a person would need to apply for such a position:

- Quarantine officer *http://www.careergov.com.au/index.php* There are number of public awareness fact sheets available for download at *http://www.daff.gov.au/aqis/about/public-awareness/education/fact-sheets* which can be used to generate discussion in the classroom.
- Students might like to consider one of the most effective quarantine measures at our borders – the quarantine detector dogs. For example, how are they trained? Who handles them? *http://www.daff.gov.au/aqis/about/public-awareness/education/fact-sheets/detector-dogs*
- Weeds officer *http://www.psv.com.au/careers-training/conservation-land-management/weed-management*
- Feral animal management *http://www.daff.gov.au/brs/land/feral-animals/apamp* is a good place to start.

UPPER SECONDARY

When native species spread beyond their natural habitats – case studies

Occasionally, changed habitats make conditions more favourable for native species. Such changes may result in population explosions in some species.

Examples include:

- Sulphur-crested Cockatoos (*Cacatua galerita*) do serious damage to grain and other crops; they are a declared pest in the southern half of WA, and unprotected west of the Great Dividing Range in NSW and in agricultural regions in VIC.
- Cootamundra Wattle (*Acacia baileyana*), also known as 'Coota-bloody-mongrel Wattle' is probably the best-known native weed. It is endemic to a small area near Cootamundra, NSW but was planted much more widely in the past because of its attractive foliage. It is a hardy species that rapidly invades bushland and has become a serious weed in Qld, NSW, VIC, SA and WA.
- The Australian White Ibis has expanded its range to Western Australia, where it was absent before the 1950s while its abundance is decreasing in its natural range. The Ibis has been labelled a pest due to its high numbers in some cities, its habit of foraging in bins and the large quantities of droppings produced in the colonies.
- *Going Batty*. Is the flying fox a vital pollinator and seed disperser of native plants and food crops, in need of protection, or a devastating pest that should be shot? The flying fox (fruit-bat) debate is always emotive; read about the damage caused in Sydney's Botanic Gardens, the Maclean High School saga and damage to crops in Queensland. What is the answer?

Use one of these examples or a similar one from your local area to help your students to research and develop a discussion on the following statement: *There is no such thing as a native pest; they have simply exploited a changed environment successfully.*

Exploring Biodiversity – a resource book of ideas for National Science Week 2001 pages 5-6 has more information on weeds and feral animals. *http://www.asta.edu.au/resources/national_science_week_resource*

Impact of Disease

The World Health Organisation defines disease as 'any condition which impairs, or has potential to impair, the functioning of an organism, or any part of it'. Organisms that cause diseases are called pathogens.

Pathogens of plants and animals may be any one of a number of fungi, bacteria or viruses. Some species of protozoans (single-celled animals), worms and insects can also cause disease or carry pathogens that cause disease. Some pathogenic species only cause disease in one species of plant or animal, while others can cause disease in many different species.

Pathogenic organisms are often a normal component of an ecosystem and naturally exist in relatively low numbers. Many plants and animals have adapted to attacks by diseases and other pests that have long been part of the Australian environment, and it is not until plants and animals are either taken from their natural habitat or end up in situations in which they are stressed that they become vulnerable to the impact of disease-causing organisms. Habitat fragmentation and disturbance are two such stressors that can influence the vulnerability of native species to disease.

In addition, when native plants and animals have come into contact with introduced diseases, fungi or parasites, they often have no natural immune responses and may not respond well to available treatments. Such diseases can affect the health of native species, reducing their ability to reproduce or survive.

Threatened species are particularly vulnerable to disease outbreaks caused by introduced organisms, because even a small reduction in the number of young born, or of individuals reaching adulthood, can result in the extinction of the species.

FROGS AND CHYTRID DISEASE

Chytrid disease is a global epidemic affecting frogs. It is caused by the chytrid fungus (*Batrachochytrium dendrobatidis*), which attacks the frog's skin and eventually causes death. It has been associated with frog declines and extinctions in Australia, New Zealand, Europe, North America, Central America, South America and Africa. Frogs living in high-altitude areas are thought to be most at risk, as infected animals are more likely to die at lower temperatures.

The origin of the fungus is uncertain, but it is likely to have been introduced into Australia via the exotic pet trade. Chytrid disease was first reported in Australia in the 1990s, but museum specimens show that it was present at least as early as 1978. The disease has so far been detected in four geographic areas of Australia: the east coast extending from Cooktown to Melbourne, Adelaide, southwestern Australia and the central Kimberleys.

Chytrid-affected frog. Source: Wikipedia

More than half of Australia's 227 frog species are found in Queensland, and 53 of these only in southeast Queensland. This puts Queensland on the front line of Australia's chytrid battle. Currently there is no treatment for chytrid disease and the only management option is to prevent its spread from affected areas.

PHYTOPHTHORA

Phytophthora is a plant disease caused by the soil fungus *Phytophthora cinnamomi*. It causes what is known as phytophthora dieback, where large areas of native forest die off. It is uncertain whether phythophthora is native to Australia, or was brought in with plant material from another country. Areas most susceptible are those receiving more than 600mm of rainfall annually.

Phytophthora is common in native vegetation throughout VIC, TAS, southern WA and SA, and coastal NSW and Qld. The fungus is known to affect eucalyptus trees, grevilleas, banksias, native peas, heaths, hibbertias, club mosses, ferns, cycads, conifers, rushes, grasses and lilies.

An outbreak of Phytophthora can destroy large tracts of native forest, which may take hundreds of years to regenerate, and, concurrently, destroy the habitat of those species dependent on the forest. Phytophthora dieback is of particular concern in the southwest region of WA, which supports a unique and globally-recognised biodiversity (see page 22). Over 40% of WA's native plant species are suceptable to phytophthora, including 50% of its rare or endangered species.

Attempts to eradicate Phytophthora have been unsuccessful. It is difficult to detect and is spread very easily via water, cars, machinery, bushwalkers and the nursery trade. At this stage the only way to manage the disease is to treat affected plants with the chemical phosphite, and to prevent its spread by quarantine and hygiene measures such as washing vehicles (including tyres), machinery and shoes when leaving affected areas.

Dieback warning sign near Mount Dale, Western Australia advising vehicles to keep out of dieback affected areas to prevent the spread of this fungus. Source: Wikipedia

Activities

LOWER PRIMARY - PRIMARY

Plants and Animal relationships – Galls and other diseases

Do you have any eucalypt trees growing in the school grounds or near the school grounds, and are any of the leaves within reach of your students? If so, have a search for galls on their leaves. To quote from *http://www.pir.sa.gov.au/forestry/publications_index/galls A gall is any abnormal growth of plant tissue caused by a reaction of the plant to secretions by an organism within the plant tissue. What is not often realised is that galls are produced by such diverse organisms as wasps, flies, beetles, psyllids, coccids, moths, nematodes and mites, as well as bacteria and fungi. They occur on leaves, stems, buds and roots.* This page also has several pictures of galls on eucalypts, with further descriptions and identification of the organism responsible for the gall. There is a pdf to download if you need to take the information away.

Ask your students to search for evidence of small animals or fungi living on plants. Fungi may be visible as a type of 'dust' or 'rust', and small insect larvae such as leaf miners form burrows through leaves. Can damage to a tree's leaves be called a 'disease'? This activity then leads to an opportunity to discuss disease and its effects on native plants and animals. (Lemon trees also often have galls and evidence of leaf miners).

MIDDLE SCHOOL - UPPER SECONDARY

Exploring Biodiversity – a resource book of ideas for National Science Week 2001 page 15 *http://www.asta.edu.au/resources/national_science_week_resource* describes an activity for investigating the galls found on plants and the organisms that cause them.

Evidence of disease in the local environment

Ask your students to collect examples or photographs of diseases in plants, such as rust, mildew, aphids, damage by caterpillars, slugs and snails, leaf curl (caused by a fungus) and rotting of parts of plants (caused by bacteria). Once back in the classroom, sort them into groups according to the type of organism that caused the damage. What organisms pose the biggest problems for local trees? Is there a reason for this? (e.g. is the environment damp? Humid? Hot and dry?)

http://www.crcplantbiosecurity.com.au/content/plant-biosecurity-primary-schools has a PowerPoint for download that has photos of sick plants that can be used to generate discussion.

The living soil

Exploring Biodiversity – a resource book of ideas for National Science Week 2001 pages 9 and 16 *http://www.asta.edu.au/resources/national_science_week_resource* describe activities that can demonstrate the nature of soil biodiversity. Page 17 has line drawings to assist in the identification of micro-organisms in soil.

Growing soil fungi - a potato garden

Each group in the class will need two plastic containers with clear sealable lids (Petri dishes are ideal), two slices of raw potato and a small quantity of soil.

Each group should set up two containers with a slice of potato in each.

Divide the soil into two portions, heating one strongly in an evaporating dish and leaving the other at room temperature. **Warning – the soil will smoke as the organic material burns.**

Once the heated soil has cooled, sprinkle a small sample of it on one potato slice in one of the containers and seal it. Similarly, sprinkle a small sample of the unheated soil on the potato slice in the second container and seal it.

Place both containers in a cool, dark place and inspect regularly over two to three weeks. **Warning – do not allow students to open these containers as the fungi and bacteria in the soil may include some that are human pathogens. The containers and contents should be destroyed unopened at the end of this investigation.**

Questions that arise from this activity as the days proceed:

1. Can the students distinguish between fungal (threadlike or filamentous structures, or with fuzzy edges) and bacterial colonies (small oval or circular spots with smooth edges) growing on the potato?
2. Can the students identify more than one type of fungi or bacteria?
3. What difference, if any, was made by strongly heating the soil? If a difference was observed, why? (Fungal and bacterial spores could have been destroyed by heat. If this occurred, discussion could include possible consequences for soils where there have been intense fires.)
4. How could the investigation be improved to:
   a. ensure that fungi and bacteria were not present on the potato rather than in the soil sample?
   b. find out if the soil contained fungi or bacteria that were harmful to plants?

http://www.soilhealth.com/ is an excellent resource with images and descriptions of soil bacteria and fungi. The site also provides newsletters with information about specific aspects of soil health, including the organisms living in the soil. Go to: *http://www.soilhealth.com/newsletter/* For example, Vol.1 No.1 has a description of an activity involving collecting mites from the soil, and also provides descriptions of the mites that could be found.

Impact of Disease in Native Species – a research task

Murray cod have also shown to be susceptible to disease from imported aquarium species. The mass mortality of Murray cod in an aquaculture facility in 2003 is believed to be attributed to a virus that entered the country from the importation of ornamental fish, namely Gourami. The outbreak of the Gourami iridovirus caused up to 90% mortality of Murray cod fingerlings in farms. The lack of host specificity of this virus means that a number of other native species may also be vulnerable to this virus including Trout cod, Mary River cod and eastern freshwater cod. Quoted from *http://www.environment.gov.au/biodiversity/invasive/publications/pubs/translocated-fish-overview.pdf* page 19

Ask your students to research the following:

1. What is a virus? *http://science.howstuffworks.com/cellular-microscopic-biology/virus-danger.htm* or *http://www.biology4kids.com/files/micro_virus.html* for younger students.
2. How do viruses spread? *http://www.netdoctor.co.uk/health_advice/facts/virusbacteria.htm* how can this be translated to fish?
3. What is a Gourami? *http://www.aquaticcommunity.com/gourami/fish.php*
4. What is Gourami iridovirus? *http://www.fishchannel.com/fish-health/disease-prevention/fish-viral-disease.aspx*

With this information, ask them to determine the controls that need to be in place to avoid outbreak of the disease in native species such as the Murray cod.

Climate change and its Potential Impacts

Dramatic changes have been a regular feature of the history of life on Earth and these changes have brought with them both large-scale and minor extinctions of many species. Paleontologists believe that global climate change was a major factor in each extinction event as each occurred over a period of approximately two million years – a relatively short time in the geological time scale.

Scientific evidence indicates that another period of climate change is in progress and the debate continues as to the exact causes and the speed of this change in comparison to earlier changes in the Earth's history. Most of the world's scientists agree that the much (or most) of the current rate of climate change is attributable to human activities.

The intricate nature of the climate system makes it difficult to predict the localised impacts on Australian biodiversity caused by climate change, however best estimates indicate that by 2030 Australia will experience a further 1ºC increase in average temperatures, up to 20% more months of drought, up to 25% increase in days of very high or extreme fire danger and increases in storm surges and severe weather events. The table below lists the possible impacts of climate change on each state and territory in Australia.

STATE	POTENTIAL IMPACTS
Qld	More intense storms, sea level rise, coral bleaching, reduction in upland tropical rainforest
NSW	Sea level rise, more intense storms, increased extreme weather event frequency (hail storms, bushfire), warming of alpine areas
ACT	Increased temperatures, increased extreme weather event frequency (high-intensity rainfall, flood, drought, bushfire)
Vic	Increased temperatures, increased bushfire risk, warming of Alpine areas, more frequent and severe drought, sea level rise
Tas	Increased temperatures, increased extreme weather event frequency (storm surges), increased coastal erosion, changed rainfall patterns, sea level rise
SA	More intense coastal storms, increased drought, increased temperatures, increased extreme weather event frequency (flash flooding), sea level rise
WA	More intense coastal storms, increased drying and drought, decrease in rainfall, sea level rise
NT	Increased extreme weather event frequency (tropical cyclones & storm surges), Top End climate hotter and drier, sea level rise

HOW WILL SPECIES RESPOND?

The range of a species is intimately linked to the climate of its environment. If climatic zones shift, which is expected under climate change, then so too will species' ranges. Some species will probably become adapted to the new conditions and some may spread to places where the new conditions are similar to the ones to which they are adapted, for example corals may, in time, move southwards down the coast of Eastern Australia. Mobile species, such as kangaroos or nomadic birds, can theoretically move to new areas where the climate and habitat are suitable. The problem for species that are able to migrate is that they must have somewhere suitable and safe to go.

Less mobile species such as plants and snails cannot migrate and will only survive if they become adapted to the new local conditions. Species with short life cycles may be able to achieve this, but for those with long life cycles, the forecasted rate of climate change is likely to be too rapid for adaptation to occur. If species are unable to migrate or adapt they will become extinct. The table below lists the characteristics of species predicted to be most and least at risk from climate change.

SPECIES LEAST AT RISK	SPECIES MOST AT RISK
Broad range of physiological tolerance to factors such as temperature, water availability and fire	Narrow range of physiological tolerance
High degree of variability in the physical appearance of individuals (phenotypic plasticity) and genetic variability	Low genetic variability
Short life cycles and high fecundity (fertility)	Long life cycles and low fecundity
Generalist resource requirements (e.g. food, nest sites)	Specialist resource requirements (e.g. requires a particular pollinator, prey species)
Good dispersal capability	Poor dispersers
Broad geographic range	Narrow geographic range

Some changes have already been observed in Australia's biodiversity that are thought to be a result of climate change. These include:

- shifts in genetic composition of some short-lived species (e.g. fruit flies),
- species range changes (e.g. the Long-spined Sea Urchin (*Centrostephanus rogersii*), currently common in NSW waters, is now becoming a pest in warming Tasmanian waters.)
- life cycle changes (e.g. earlier mating in the Shingleback lizard),
- reduced reproduction associated with higher temperatures (e.g. Wedge-tailed Shearwater),
- changes in migration patterns, with many birds (including Australian species) migrating earlier in spring and later in autumn.
- shifts in ecotonal boundaries (e.g. rainforest expansion in NT, Qld and NSW). An ecotone is a transitional area between two adjacent but different plant communities, such as forest and grassland.
- ecosystem-wide responses (e.g. coral bleaching on the Great Barrier Reef)
- changing disturbance regimes (e.g. fire regimes due to hotter, drier conditions).

Activities

PRIMARY – MIDDLE SCHOOL

Have temperatures in Australia changed?

Are your students able to go to the environment officer of the local council and see if they can obtain temperature records for previous years? If they are available in tabular form, upper primary students might be able to graph them. Perhaps they could then start collecting school data as a foundation resource for the use of future classes – or even be encouraged to start individual long-term data collection projects.

The Symbiosis Game

In discussing the effect of climate change on single species, students need to be reminded of the overall impact of species loss on an ecosystem. If one species disappears from a food chain or food web, the entire ecosystem is likely to be at risk. The example of coral bleaching can used use to illustrate this effect. *http://striweb.si.edu/PDFs/culebra_education_eng/lets_work_on_groups.pdf* has a series of activities based on a Northern Hemisphere coral reef community. It elegantly demonstrates the complex inter-relationships that exist in this community, which easily can be compared to the Australian marine environment. You will need to make up cards with Australian animals, to replace the Northern Hemisphere ones on the site. *http://www.gullivermedia.com.au/reef.html* will help you to illustrate the various relationships. Detailed information is available at *http://www.aims.gov.au/pages/research/project-net/apnet-alpha.html* Perhaps finding out about the animals of the coral reef and making up the cards could become a whole-class project.

If you need more ideas to translate into marine education on the Australian environment, consider adapting some of the lessons at: *http://www.stri.org/english/visit_us/culebra/education.php* and *http://www.redmap.org.au/resources/teaching-resources* which have Australian-based teaching resources.

Species at Risk

Ask your students to identify a local plant or animal which is a species at risk of decline or extinction due to climate change. They can develop a display such as a PowerPoint presentation or static poster, with the following information:

- name – common and scientific and classification at class or phylum level (such as reptile, amphibian, angiosperm [flowering plant], fern)
- current range – with notes about both its distribution and abundance
- current threats to its survival in its habitat
- predicted impacts of climate change. Can anything be done to reduce the risk of decline or extinction?
- some websites to begin the research include:
  http://australianmuseum.net.au/Australian-species-vulnerable-to-climate-change
  http://www.science.org.au/nova/091/091key.htm
  Impact of global warning on biodiversity.

UPPER SECONDARY

The True Story of Climate Change

The causes and effects of climate change continue to be hotly debated around Australia and the world. Because it is such a 'hot topic', this debate provides an excellent opportunity to introduce students to the importance of referencing resources. Many of the so-called experts being quoted, particularly among the 'climate change sceptics', have no training in the science of climate change. By the same token, 'climate change believers' may also make claims that cannot be backed up by current science. Add politics and the state of the economy into the mix and the *Science as a Human Endeavour* strand of the Australian curriculum becomes a crucial component of science classroom discussion and debate.

Among several options that will enhance the scientific literacy of your older students are:

1. Organise a class debate on the truth or otherwise of the statement *'Climate change is not occurring'*. Give students time to collect all the data they will need to support their arguments.

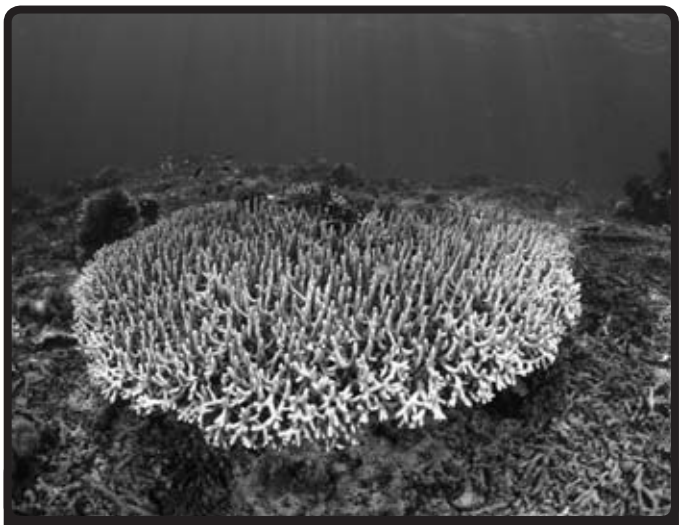
   Important features of preparation for the debate should include advice on:

   - How to evaluate references with evidence for and against climate change such as:
     How consistent is the information compared with information from other reputable sources?
   - What is a reputable source?
   - Are the data presented based on repeatable/repeated processes?

     (*http://www.actdu.org.au/archives/actein_site/basicskills.html* has the basic rules of debating.)

2. Consider the influence of politics on the scientific debate about climate change. Able older students may enjoy reading the paper at *www.naf.org.au/kellow.rtf*

Younger students can be guided to prepare a report on the evidence for climate change. *http://www.bom.gov.au/climate/change/* is a good place to start as it contains a number of data sources and links to further information. Do your students need some help in assembling a science information report? *www.decs.sa.gov.au/curric/files/links/Information_reports1.ppt* is a very detailed account, while *http://www.sac.sa.edu.au/Library/Library/Topics/Literacy/information.htm* has a basic scaffold.



Coral bleaching. Image: iStock

The Role of Indigenous Australians in Biodiversity

Indigenous people living in remote areas have an important role to play in biodiversity conservation. Without the assistance of people in these areas, there is a risk of environmental problems such as feral animals, pest species invasions, habitat degradation, and illegal fishing remaining both undetected and uncontrolled. Indigenous lands, including outside Indigenous Protected Areas (IPAs), are some of Australia's great wildernesses and their biodiversity values must be protected.

Some of Australia's most ecologically important wetlands (including Ramsar sites) are found in Indigenous-owned lands in the Top End and Cape York. The wetlands of northern Australia are much less disturbed than those in the south and provide important habitats for a variety of native species, including migratory birds.

INDIGENOUS RANGERS

The Indigenous Ranger program was born out of recognition of the need for formal environmental management within Indigenous lands. The Australian government currently funds ranger operations, but the long-term aim is for the groups to become self-sufficient through commercial activity. There are currently 300 Indigenous Ranger positions funded throughout WA, NT, Qld and NSW and this is set to expand over the next five years.

Rangers are engaged in land management activities such as weed and feral animal control, coastal surveillance, AQIS work, fauna and flora surveys and enterprise operations such as crocodile egg harvesting and turtle farming. In the Northern Territory, saltwater crocodile (*Crocodylus porosus*) eggs are already harvested legally and sustainably from the wild to supply crocodile farms, which produce meat and leather products. Egg harvesting provides a source of income for Indigenous communities and is a necessary part of the industry, as the saltwater crocodile does not breed well in captivity.

THE NORTHERN TANAMI

The Northern Tanami, a declared IPA, has an unbroken history of Aboriginal traditional use and management. The development and availability of local land management programs are of increasing importance in the conservation effort, both in terms of community education and on-ground capacity for practical efforts such as predator control.

Relatively free of the impacts of western land uses, the vast Tanami Land Trusts are sanctuaries for fragile desert flora and fauna. Endangered terrestrial vertebrates in the arid rangelands include the Northern Marsupial Mole, Greater Bilby, Ampurta, Greater Desert Skink, Central Rock-rat, Common Brush-tailed Possum and Night Parrot. The Central Land Council plays a fundamental role in informing traditional owners of the status of, and threats to, each species as they are of increasing national conservation significance.

ACTIVITY

Given the isolation of this IPA, it is unlikely that many students will be aware of the fragile ecosystems protected in this region. *http://www.clc.org.au/Looking_after_Country/ipa.html* has several sections that are worth exploring to give students a sense of the value of protecting such areas in terms of threatened species, Indigenous knowledge of flora and fauna and the cultural significance of the country.

MANAGEMENT OF *MIMOSA PIGRA*

One of the major threats to the wetlands of northern Australia is Mimosa (*Mimosa pigra*). Mimosa is considered to be one of the worst weeds in the world. It is a woody, thorny shrub growing to 6m that forms dense, impenetrable monocultures in swampy or seasonally inundated areas.

Mimosa was first planted in the Royal Darwin Botanic Gardens in 1891 and now infests more than 85,000 hectares of wetland across the Top End. Ecological impacts associated with Mimosa infestation include loss of native wetland flora species, loss of bird nesting and feeding habitat, loss of access to waterholes and sacred sites and sedimentation of the floodplain.

A large proportion of the work carried out by rangers in western Arnhem Land is related to Mimosa control. The species is very difficult to control as it is hardy, produces large quantities of seed that last up to 20 years and grows in wetland areas that are, for the most part, infested with crocodiles! Top End Indigenous Ranger groups are working hard to control Mimosa and are slowly reducing its extent.

ACTIVITY - THE FUTURE CONTROL OF MIMOSA

Set up a classroom discussion on the advantages and disadvantages of various methods of weed control. The current methods of control of this weed involve spraying with chemicals and strategic use of fire. The role of community in controlling this weed can also be discussed via *http://www.weeds.gov.au/publications/guidelines/wons/pubs/m-pigra.pdf* *http://www.csiro.au/science/MimosaBiocontrol.html* has information on the CSIRO's efforts to find a method of biological control.

Mimosa, one of the worst weeds in the world. Image: Stock.xchng

Conserving Australian Biodiversity

CHAPTER 4

Australian Wild Orchid. Image: iStock

All native species in Australia are protected by law. When a species or community becomes very rare as a result of human activity and is threatened with extinction, it can be placed under special State or Commonwealth (Australia-wide) threatened species legislation. Under this legislation, activities cannot be carried out that harm the species or its habitat.

COMMONWEALTH LEGISLATION

If a species is threatened in several states, or is threatened and has only a limited range, it is listed under a special piece of Commonwealth legislation called the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Species listed under the EPBC Act are protected across the whole of Australia.

Species are classified as either extinct, extinct in the wild, critically endangered, endangered, vulnerable or conservation-dependant according to how threatened they are. A classification of extinct means a species is assumed to be no longer in existence, whilst conservation-dependant describes a species that is not at major risk.

Tasmania's Orchids – Protected under Commonwealth Legislation

There are 195 native orchid species recorded in Tasmania, of which some are endemic and others are non-endemic to that State. Thirty-two of these are listed as threatened under the EPBC Act. Of these, twenty endemic species have been classified as critically endangered. Because these orchids have only a limited range, their protection is considered to be of national importance.

STATE LEGISLATION

Each State and Territory in Australia (except the ACT) has its own legislation that lists species threatened in that State or Territory. The legislation classifies species into categories depending on how threatened they are and each State has its own classification system.

For example, in Queensland a species can be classified as:

- extinct in the wild (e.g. Paradise Parrot),
- endangered (e.g. Cassowary),
- vulnerable (e.g. Flatback Turtle),
- near threatened (e.g. Golden-tailed Gecko)
- of least concern (all other native species).

Some species may be listed as threatened in one State or Territory but not in another. For example, the Brolga (*Grus rubicundus*) (one of Australia's largest birds), is listed as threatened in NSW, VIC and SA, but not in WA, NT and Qld. This is because in the southern part of their range (NSW, VIC and SA), brolgas have lost much of their habitat to clearing, wetland draining and agriculture, whereas in the northern part of their range (WA, NT and Qld), wetland systems have been less disturbed and are still able to support large numbers of brolgas.

Brolga, NT.

Protection and Prevention

In earlier discussions of invasive species, it was noted that any species might disturb the balance of an ecosystem if it has not evolved as part of that ecosystem. Whilst native species can become pests, species introduced from outside Australia into Australian ecosystems are of much greater concern because of their potential to destroy, compete with or replace native species in their habitats. Protection of Australian biodiversity is best achieved by keeping out potential competitors!

QUARANTINE: PREVENTION IS BEST

Australia's flora and fauna have evolved in isolation from the rest of the world (see page 17 on Australian Biogeography). This means that native species often do not have defences against, and cannot compete with, species from overseas. Introduced or exotic species have had a devastating impact on Australian biodiversity and as the world becomes more globalised, the risk of such species entering Australia has increased.

To keep exotic species out, the Australian Quarantine and Inspection Service (AQIS) carries out routine quarantine control measures. The aim of quarantine is to prevent the introduction, establishment and spread of animal, plant or human pests and diseases. Feral animal and pest impacts are estimated to cost Australia about $1 billion per year so it is always cheaper to keep a potential pest out rather than manage the impacts once it is here. Australia currently has the toughest quarantine standards in the world. Many Australian agricultural products are threatened by the possible introduction of microscopic pathogens and many quarantine controls are concerned with preventing the importation of material that may contain disease-causing organisms.

NORTH AUSTRALIAN QUARANTINE STRATEGY (NAQS)

The northern coastline of Australia presents a unique challenge for quarantine control. It is very close to Papua New Guinea, Indonesia and Timor, so exotic species do not have to travel far to reach Australia, and an exotic incursion would be relatively easy. The area is so sparsely populated that such an incursion is likely to go undetected.

To deal with quarantine threats on the northern coastline, a special program called the North Australian Quarantine Strategy (NAQS) has been developed. The NAQS zone covers the coastline from Cairns (Qld) to Broome (WA), Tiwi Island, Groote Island and the Torres Straight. NAQS targets weeds, and pests and diseases of plants and animals that are likely to come in from countries north of Australia and become established in our tropical regions.

Much of the northern coastline is under Indigenous ownership, so NAQS engages Indigenous rangers to assist with surveillance activities along the coast. Rangers are involved with activities such as feral pig blood and tissue sampling (to detect diseases such as Foot and Mouth Disease), insect surveys and illegal fishing boat inspections.

Siam Weed

Siam Weed (*Chromolaena odorata*) is an example of a NAQS Priority Species. It forms dense, impenetrable thickets up to 2m high and can climb high up into tree canopies, smothering vegetation. It grows in tropical and subtropical environments and it is a serious weed in Africa and Asia. Siam Weed has infested virtually all of Timor in only 20 years. It has the potential to establish in the tropics and subtropics of Australia, where it could degrade World Heritage-listed rainforests and agricultural land. Some small infestations were discovered in Tully in Far North Queensland in 1994 and were targeted for eradication. Queensland remains on alert for further infestations.

Siam Weed. Source: Wikipedia

MARINE QUARANTINE

With so much traffic on our oceans these days it is very easy for marine species to hitchhike across oceans. Sea-going vessels take on water in their ballast tanks to help with buoyancy and stability. Ballast water is often taken on at one port and discharged at another, along with any marine animal or plant hitchhikers. It is likely that the Northern Pacific Seastar (*Asterias amurensis*), one of our worst marine pests, made its way to Australia in ballast water. There are now strict regulations governing the management of ballast water to help prevent further introductions of potential pests. Exotic marine species also reach Australia via petroleum, fishing, non-trading and recreational vessels, as well as through the aquaculture and aquarium industries.

Example of quarantine failure: Fire Ants

Unfortunately pest species do occasionally make it through our border controls. One example is the Fire Ant (*Solenopsis invicta*). Fire Ants, which are native to South America, have become a serious pest in North America where they have invaded over 110 million hectares of land. They are undesirable because of their nasty sting; an encounter with Fire Ants will usually involve tens or hundreds of ants all stinging at once. Fire Ants were first detected in Brisbane in 2001, but authorities are not sure how they arrived. Their distribution is currently limited to the south-western suburbs of Brisbane. The Queensland government is currently carrying out an eradication program, which has significantly reduced the number of ant colonies.

Activities

PRIMARY

Camels in Australia A. Lane and V. King Barrie Publishing Pty Ltd ISBN1-74065-455-2 is a small reader that explains the history of the camel in Australia. It includes information on feral camels, their impact on the environment and how camels are used today.

PRIMARY – MIDDLE SCHOOL

Do you have Prickly pear, rabbits, blackberry, lantana or cane toads in your region? Whilst it will be sufficient for younger students to find out about two historic examples of introduced pests, older students can be introduced to the concept of biological control – the control of pest organisms using other organisms (usually introduced) as predators, parasites, or pathogens of the pest. The following examples demonstrate the importance of careful research prior to the release of an agent of biological control. A compare and contrast, or success v failure, analysis of these two stories could lead to discussions of important risk management strategies involving biological control mechanisms.

Prickly Pear – a success story

Prickly Pear had a devastating impact on life in rural eastern Australia during the early part of the 20th century. Scientists have been successful in managing this weed by finding an insect that eats it. *http://aso.gov.au/titles/newsreels/australasian-gazette-prickly/clip1/* is a silent newsreel from the 1920s that shows bushland in eastern Australia infested by with the noxious Prickly pear cactus and the efforts of scientists to combat the problem using cochineal insects. On the same page, a separate tab opens with further teaching notes about the clip from the eLearning Federation.

Cane Toads – definitely not a success story

Cane toads, natives of Central and South America, were first introduced to Australia in 1935. More than 3000 individuals were released into sugar cane plantations in northern Queensland as a means of controlling the introduced French's Cane Beetle and the Greyback Cane Beetle, which were causing significant damage to sugar cane crops. Cane toads are now a serious threat to Australia's biodiversity and ecosystems. Your students could investigate:

1. the current distribution of cane toads in Australia
2. the documented impact of cane toads on Australian native species
3. community campaigns aimed at reducing cane toad numbers
4. current scientific investigations into methods of controlling cane toads
5. how the lessons learned from this problem can inform current ideas on quarantine and pest control?

http://www.frogsaustralia.net.au/conservation/cane-toads.cfm is a good place to start as it has further links to northern and eastern Australian resources.

Cane Toad. Image: iStock

The Weedbuster Program

This is a community-based program that commenced in Queensland and has spread, not only through Australia but also to New Zealand and South Africa. For more information, go to *http://www.weedbusterweek.info.au/about.htm*

In the context of Australian biodiversity, introduce your students to some weeds that threaten the habitats or health of native plants and animals. Your students may be surprised to learn of the number of weeds that have 'escaped' from domestic gardens to become serious pests. For example, one of northern Australia's most significant weeds, the giant sensitive plant, *Mimosa pigra*, started off as an introduced ornamental plant which remained unnoticed in the landscape for many decades until it became a serious pest in the 1980s. (see p38) Many councils have Noxious Weed Officers who can provide information about local problems.

Across Australia, various weeds of national significance have been identified. A full list is available at *http://www.weeds.org.au/natsig.htm* Ask your students, working in groups, to research one of these weeds, collect information about it and present their findings to the class as a poster, PowerPoint or audiovisual display. The information they present should include:

- name of weed, its origins and why it was introduced to Australia
- how to recognise the weed
- its distribution in Australia
- the threats it presents to Australian biodiversity
- ways in which itcan be managed.

Weedbuster activity book with Teachers' Resource – Queensland-based http://www.dpi.qld.gov.au/documents/Biosecurity_EnvironmentalPests/IPA-Weedbuster-Activity-Book.pdf This 35-page booklet has a wide range of information and related activities on Queensland weeds for download. It is well worth downloading, as the activities range in level of difficulty and offer links to further information. Teachers in other States will be able to adapt some of the activities for local conditions.

UPPER SECONDARY

Biosecurity Strategies

As well as preventing new animal and plant pests, diseases and weeds from arriving in Australia, biosecurity involves controlling those already present. It concerns all of us and the community is encouraged to take responsibility for its actions and help prevent the introduction and spread of animal and plant pests, diseases and weeds. Quarantine measures can effectively limit risks to terrestrial ecosystems

Older students should be able to extract information on marine biosecurity risks from the report at: *http://www.daff.gov.au/__data/assets/pdf_file/0007/671470/105b-amc-sub.pdf*

Ask them to develop a flowchart that identifies potential risks and ways in which these risks can be managed to prevent further intrusions of exotic species and diseases into Australian marine ecosystems. *http://www.hci.com.au/hcisite2/toolkit/flowchar.htm* has instructions on how to draw a flowchart.

Saving Ecosystems

Everything humans need, have needed, or will need comes from ecosystems. The direct and indirect benefits provided by ecosystems to humans are known as ecosystem services. In the past Australians have taken these 'free' services for granted, but as our ecosystems become degraded and the services compromised, we have begun to realise how dependent we are on healthy, functioning ecosystems.

WHY CONSERVE ECOSYSTEMS?

Some researchers have tried to assign a dollar value to ecosystem services based on what it would cost to artificially replicate the services, if this were even possible. It has been estimated that Australian ecosystems provide goods and services worth at least $1,300 billion per year!

Ecosystems are of value in the following ways:

- Direct benefits to humans (e.g. food, water, materials and medicine)
- Indirect benefits to humans (e.g. oxygen production, carbon dioxide absorption, waste breakdown, flood mitigation, groundwater recharge, crop pollination)
- Cultural (e.g. recreation, ceremony)
- Aesthetic (e.g. relaxation, artistic creativity)
- Spiritual - spirituality is linked to the natural environment for many people,
- Intrinsic value - all living things have value regardless of their worth to humans.

THE NATIONAL RESERVE SYSTEM

Ecosystems are formally protected in Australia through the National Reserve System (NRS) The NRS is a network of more than 9000 protected areas covering more than 11% of the country. The Australian landmass has been divided into 85 bioregions and 403 subregions, based on ecological characteristics. One of the purposes of basing the NRS on ecological characteristics is to ensure that each bioregion and subregion is represented in the reserve system. Some examples of bioregions are the Great Sandy Desert (WA/NT), Eyre Yorke Block (SA) and Gulf Plains (Qld).

At the moment all 85 bioregions and 264 of the subregions are represented in the National Reserve System, although some have more examples than others. The priority is now to conserve areas that are poorly represented in the reserve system. A network of Australian marine areas is also protected under the Environment Protection and Biodiversity Conservation Act 1999. A map of these reserves is available at *http://www.environment.gov.au/coasts/mpa/index.html*

Protected areas include commonwealth, state and territory reserves, Indigenous lands, and protected areas managed by non-profit organisations (e.g. the Australian Wildlife Conservancy). These areas may have names such as national park, conservation reserve or Indigenous protected area. Over 80% of these areas (about 72 million hectares) are publicly owned and managed either by commonwealth, state or territory governments. About 2% are in Indigenous Protected Areas (IPAs) and 0.3% on privately-owned land.

SOIL IS THE BASIS OF ECOSYSTEMS

Soil is one of our most important resources and naturally contains a variety of macro and micro flora and fauna species including bacteria, fungi and invertebrates. These soil biota are essential for soil fertility. They perform important functions such as breakdown of organic matter and maintenance of soil structure (e.g. aeration, permeability, drainage and organic matter content). Termites, ants and earthworms are considered to be the ecological engineers of the soil environment, due to their profound influence on soil structure and fertility.

Australian soils are typically highly leached, nutrient poor and have a thin topsoil layer, which is a product of our ancient geology. Soil degradation is caused by the loss of, or damage to native vegetation through direct removal or overgrazing and intensive farming practices. There are now increased efforts to move away from intensive chemical use (pesticides and synthetic fertilisers) towards chemical-free methods of farming that focus on improving soil microbiology because of the importance of microbes for plant growth.

BOUNCEBACK: FLINDERS RANGES

Bounceback is the name of a landscape-scale restoration program underway in the Flinders and Gammon Rangers National Parks in SA. Pastoral operations were established in the region from the mid 1800s onwards and more than a hundred years of inappropriate farming practices have left the fragile semi-arid environment highly degraded. The main forms of degradation were soil erosion due to over-grazing and loss of native vegetation, weed incursion (e.g. onion weed, horehound and Salvation Jane/Paterson's Curse), damage by feral animals (foxes, rabbits, cats, goats and donkeys) and sedimentation of waterways.

Habitat degradation led to localised extinctions of many native species including the Yellow-footed Rock Wallaby (*Petrogale xanthopus xanthopus*), now listed as vulnerable under the EPBC Act. Although the national parks were destocked of introduced grazing animals, there was little regeneration of native plants or improvement in soil condition and habitat quality.

The Bounceback program commenced in 1992, with the aim of significantly restoring the landscape. Restoration activities included the control of pest species and weeds, management of grazing pressure, revegetation and fauna reintroductions. Recovery in rangeland environments is a slow process due to unreliable and erratic rainfall, but some positive results have been achieved.

Successes include a reduction in pest species numbers, the regeneration of some native vegetation, control of some weed species, an increase in Yellow-footed Rock Wallaby numbers and a trial reintroduction of the Brush-tailed Bettong/Woylie (*Bettongia penicillata*).

Activities

ALL LEVELS

Can you start a 'bounceback' at your school?

Exploring Biodiversity – A Resource Book for National Science Week 2001 (pages 33-34) describes a long-term biodiversity project that could re-introduce native species to the school environment. Download the booklet from: *http://www.asta.edu.au/resources/national_science_week_resource*

LOWER PRIMARY

Wet L Flaherty Blake Education ISBN 978-1-74164-504-0 is one of a series of four books that focuses on habitats in which living things exist and the adaptations they need to live in each environment. *Wet* provides an introduction to and talking points about animals in wetlands. (If you wish to focus on Australian plants and animals only, ignore the last four pages about the Bengal Tiger and the Hippopotamus.)

To begin to build awareness of the need to care for the environment, use this little book as a starting point for a notice board display of plants and animals in a wetland, the foods and shelter they need, where they nest and threats such as rubbish or pollution in the water.

PRIMARY

Helping Ecosystems

What can your students do to help ecosystems recover? 'Think Globally, Act Locally'? 'Refuse, Reduce, Reuse, Recycle'? Can they be better at managing waste? Are there possibilities for more recycling? What do they do with their rubbish? How can they help the school to:

- decrease waste and litter produced?
- reduce energy consumption?
- reduce water consumption?
- increase biodiversity in the school grounds?

Can you make the link between these goals and helping ecosystems? *http://www.learningtogive.org/lessons/unit62/lesson5.html* has a lesson that can be adapted to the Australian context.

Wetlands – An integrated unit of study

The Queensland Wetlands Program, in partnership with the Great Barrier Reef Marine Park Authority, has developed and referenced various learning materials for use in the classroom. These learning products range from single-lesson activities to a field-based, 10-week curriculum unit that addresses outcomes as outlined by the Queensland Studies Authority. The teachers' resource book provides step-by-step instructions on how to implement the program, which raises awareness of the need to care for wetlands. *http://www.epa.qld.gov.au/wetlandinfo/site/spreadtheword/GBR/Curriculum.html#storythread*

MIDDLE SCHOOL

Exploring Local Wetlands

The page below outlines a comprehensive list of activities associated with a wetland study. Well worth a visit if your region includes a wetland ecosystem *http://www.reefed.edu.au/home/teaching/primary_units/exploring_local_wetlands*

MIDDLE SCHOOL – UPPER SECONDARY

Many landscapes in regional, rural and remote Australia have been disturbed by development, agriculture and mining. Steps need to be taken because *"the natural resources we depend on will not be there in the form or style, or at the standard that is going to be required for our future."* Paraphrased from a speech by Mr David Butcher, Worldwide Fund for Nature, 23 April 2003. Our students need to be made aware that it is every citizen's role to preserve our biodiversity, in appropriate ways, at the local level.

At Australian government level, the National Reserve System is underpinned by a scientific framework to ensure the protection of examples of all our ecosystems, with their distinctive flora, fauna and landscapes. Ask students to identify a priority area for biodiversity conservation in your State and present information that explains the importance of this area for Australia. *http://www.environment.gov.au/parks/nrs/science/index.html* is the best place for them to start this research trail.

Across Australia, many community organisations are working to restore ecosystems and thereby restore habitats to assist in the preservation of biodiversity.

The map at *http://www.globalrestorationnetwork.org/countries/australianew-zealand/australia/* shows internationally acclaimed restoration projects across Australia.

Ask your students to identify those happening in your State and summarise:

- Why the rehabilitation was necessary
- What work is being done
- Any evidence of progress.

It is interesting to note that no projects have been identified in the NT. Perhaps environmental degradation is not as bad in the NT, or regions of environmental degradation may not yet have been identified? Your students might like to find out why this is so. How would they go about this?

At community level, there will also be organisations assisting in environmental repair. What is happening in your community? Invite one of these organisations, such as Landcare, to speak at your school. Is there any way in which your students can become involved in local projects? Use the list on page 5 to begin a search for community projects in your area.

Explore your local wetlands. Image: iStock

Saving Species

Humans are dependent on the services that ecosystems provide. Each ecosystem is made up of species and their physical environments, all of which contribute towards the functioning of that ecosystem. It is therefore in the interest of humans to conserve species.

WHY SAVE SPECIES?

Some species are known to have an influence on an ecosystem that is disproportionate to their abundance. These species are known as keystone species. The Cassowary (*Casuarius casuarius*) is an example of a keystone species. It eats native fruits and disperses the seed around the forest via its faeces. This process is important for regeneration of the rainforest plants, upon which many other species are dependent.

CONSERVATION SUCCESS STORIES

Saltwater Crocodile

The saltwater crocodile (*Crocodylus porosus*) is a conservation success story. 'Salties' are found in the coastal rivers, estuaries and swamps of northern Australia between Broome in WA and Maryborough in Qld. They were once found throughout SE Asia, but are now thought to be extinct in the wild in all countries within their SE Asian range except Papua New Guinea and perhaps Myanmar.

Saltwater crocodiles were hunted extensively in Australia between the 1940s and 1960s for their skins. During this period, wild populations crashed and governments and conservationists began to fear that the species was on its way to extinction. Subsequently it was listed as a protected species in WA, the NT and Qld.

Although it is difficult to establish population levels in the early 1900s, scientists think that that the wild population may have bounced back to pre-hunting levels as a result of its protected species status. Populations in remote areas of the NT and WA have experienced the greatest recovery, while Qld still lags behind due to east coast development impacting on crocodile habitats. It is possible that in some areas, present-day crocodile populations may even exceed pre-hunting levels as some Indigenous people are no longer hunting the species.

Scientists estimate that there are now about 150,000 saltwater crocodiles in the wild, making northern Australia a stronghold for the species.

Saltwater Crocodile. © Margaret Watts 2009

Quolls

Quolls are small carnivorous marsupials native to Australia and New Guinea. There are six species of quoll, four of which are found in Australia. Quoll populations have been in decline due to habitat loss and degradation as well as competition with introduced predators such as cats and foxes.

COMMON NAME	SPECIES NAME	DISTRIBUTION	CONSERVATION STATUS
Northern Quoll	*Dasyurus hallucatus*	Northern WA, NT and Qld	Endangered (EPBC)
Spot-tailed Quoll	*Dasyurus maculatus*	Qld, NSW, Vic and Tas	Endangered (EPBC)
Eastern Quoll	*Dasyurus viverrinus*	Tas	Endangered (NSW)
Western Quoll	*Dasyurus geoffroii*	Southwest WA	Vulnerable (EPBC)

Unfortunately, quoll numbers have been further reduced by cane toad incursions. Since native frogs form part of the quolls' diet, cane toads are a natural inclusion on the menu. Once the toad is in the quoll's mouth poison is exuded from the toad's paratoid glands (swellings behind the eardrum) killing the quoll in as little as 10 minutes.

Cane toads were first sighted in the east of the NT in 1984. When they reached the Mary River district in 2001, it took only two years for the northern quoll to become locally extinct. A cascade of local extinctions has accompanied the arrival of cane toads in new areas and the northern quoll (*Dasyurus hallucatus*) is one of the latest casualties. The northern quoll, which is found across the north of Australia, is currently experiencing rapid declines as the toads march westwards towards WA.

Out of fear that the NT would lose its entire northern quoll population, a relocation program was initiated. The program is a collaboration between several government, semi-government and community groups. At the beginning of 2009, 65 quolls were captured from toad-free areas. The quolls were microchipped, genetically profiled and then released onto selected islands off the Arnhem Land coast. Islands were selected that were remote, toad free, contained suitable habitat, were large enough to support a sustainable quoll population but were unlikely to be impacted detrimentally by the quolls. Follow-up surveys have revealed that the quolls are healthy and reproducing, so the program has been a success up to this point. The long-term plan is for the quolls eventually to be reintroduced onto the mainland.

Activities

ALL LEVELS

Restoring Biodiversity at your School

Exploring Biodiversity – A resource book for National Science Week 2001 pages 35-37 describes a number of projects which could provide habitat for local species in the school environment. Download the booklet from: *http://www.asta.edu.au/resources/national_science_week_resource*

LOWER PRIMARY

Harriet's Race to the Reef P. Adams and L Wilson, Knowledge Books and Software, ISBN 174162041-4 is the story of a hatchling turtle's dangerous journey across the beach to the safety of the Great Barrier Reef. Turtles are particularly vulnerable during their incubation under the sand, their hatching and traversing the beach to reach the sea. This could lead to a discussion of how the turtles' hatching site could be protected. It can also stimulate discussion about the importance of keeping the sea clean, and the dangers of plastic bags to sea creatures.

For more information about turtles and their life cycles, *http://www.ningalooturtles.org.au/jurabi.html* is an excellent site crammed with information, including well-designed downloadable information posters.

PRIMARY

Bird watching

Even the arrival of a regular visitor species can alter the behaviour and environment in a habitat. For example, the Channel-billed Cuckoo lays its eggs in the nests of the Australian Magpie (*Gymnorhina tibicen)*, the Pied Currawong, (*Strepera graculina)* and members of the crow family (Corvidae). The cuckoo chicks do not evict the host's young or eggs from the nest, but simply grow faster and demand all the food, thus starving the others. Often the adult female will damage the existing eggs in the nest when she lays her own and she may even lay more than one egg in a single nest.

Set up a system to allow students to monitor migratory bird arrival times in your local area. What are the immediate effects on local plants and animals? *http://www.ausbird.com/* is the place to begin such a project.

The Glossy Black-Cockatoo

Glossy Black-Cockatoos (*Calyptorhynchus lathami*) are one of the more threatened species of cockatoo in Australia and are listed as vulnerable in Qld and NSW. The South Australian Glossy Black-Cockatoo is endangered because of habitat loss and nest predation. There is ample information on the Internet for your students to research this bird and prepare an information poster to help save it from extinction. Focus your students on finding out about:

- How and why the Glossy Black-Cockatoo has become a threatened species.
- What steps are being taken to save the species in NSW, Qld and SA.

http://www.environment.sa.gov.au/biodiversity/pdfs/glossy_black_brochure.pdf has South Australian information. *http://www.glossyblack.org.au/pdf/Fact_Sheet_Living_with_Glossy_Blacks_Development_control.pdf* has NSW and Qld information.

As a long-term project, your students could grow food trees from seed, and plant them if your area is home to this threatened cockatoo.

MIDDLE SCHOOL

Plant watching

Following on from the bird watching activity described above, students could be asked to combine two sets of observations and look for inter-relationships within them.

As well as a field guide for the identification of birds, you will need a guide to identify native plants in the area. *http://asgap.org.au/sgap1a.html* is a helpful site for plant identification. Ask your students to monitor flowering and fruiting times and migratory bird arrival times in your local area. What are the immediate effects on other plants and animals? Is it possible to find relationships between bird arrivals and departures and the flowering or fruiting of native plants?

MIDDLE SCHOOL - UPPER SECONDARY

Australia – An Ark for Vanishing Species?

The following scenario would be an interesting problem-based learning activity for Year 8-10 students. Ask them to work in groups to address the scenario question.

In order to argue a response to this question, students will need to gather information on:

- The fragile nature of Australian ecosystems and their carrying capacities in terms of plants and animals
- The existing food chains and food webs in Australian ecosystems
- The nature of Australian soils and the impact of hooved and other animals on these soils
- Water availability
- Food resources consumed by large introduced animals.

The scenario: In November 2009, a hunter in the NT shot a pigmy hippo, mistaking it for a feral pig. The hippo, a native of the swamps of West Africa, and in particular Liberia, had apparently survived for over six years in the NT bush after escaping from a zoo. In light of this survival story, should Australia be considering acting as a refuge for other exotic species? It appears from this article that some of them could survive here. *http://www.theaustralian.com.au/business/property/rare-animals-under-threat-as-safari-operator-prepares-to-let-them-loose/story-e6frg9gx-1225808813966*

Provide your students with the following news item: *http://www.smh.com.au/environment/conservation/cant-save-them-move-em-20100310-pzgk.html*

Suppose Australia was asked to assist in a future animal rescue? Ask your students to decide what would be a suitable response. What evidence supports their opinion?

Quoll. Image: Wikipedia

Saving Genetic Diversity

Genetic diversity plays a very important role in the survival and adaptability of a species because when a species' environment changes, even slight genetic variations make it possible for changes to occur in the organisms' anatomy or physiology that enable them to adapt and survive.

A species that has a large degree of genetic diversity amongst its population will have more variations that might affect the ability of the organism to survive in its existing habitat, or allow it to survive in more diverse habitats. Genetic diversity within a species is also crucial when disease threatens that species.

For example, while some individuals of a species might be able to tolerate an increased load of pollutants in their environment, others, carrying different genes, might suffer from infertility or even die under the same environmental conditions. The former can continue to live in the environment but the latter will either have to leave it or die. This process is called *natural selection* and it leads to the loss of genetic diversity in certain habitats and under certain environmental conditions.

Species that have very little genetic variation are thus at greater risk of extinction. If very little genetic variation exists within a species, healthy reproduction becomes increasingly difficult, and offspring often face similar problems to those caused by inbreeding including increased vulnerability to disease.

DINGOES: PEST OR THREATENED AUSTRALIAN SPECIES?

Genetic and archaeological data indicate that dingoes (*Canis lupus dingo*) arrived in Australia between 3,500 and 12,000 years ago. Dingoes are genetically distinct from other *Canis lupus* subspecies such as wolves and domestic dogs. It is believed that pure-blood dingoes are becoming rarer due to interbreeding with wild dogs. There is great debate about whether dingoes should be listed as a threatened species to protect pure strains that still exist. Others argue that a dingo should not be defined by its genetic purity, but rather by its ecological role and cultural value.

Fraser Island in Queensland is believed to be one of the genetic strongholds for dingoes, with the largest genetically-pure population on the east coast of Australia. It was given World Heritage listing in 1991 and has since been managed as a national park, meaning all its flora and fauna are protected.

Management of the dingo is a complicated matter. In national parks in NSW and Qld, all native wildlife, including dingoes, is protected. However outside these areas, the dingo is a declared pest and is 'managed' accordingly (i.e. shot or baited). The problem for national parks managers is distinguishing between 'pure blood' dingoes and wild dogs.

In 2008, dingoes were listed as an endangered species under Victorian legislation, which was an Australian first. However, under the legislation farmers are still permitted to destroy dingoes that attack livestock. In SA, dingoes are a declared pest south of the dog fence, but protected as native wildlife north of the fence. They are a declared pest in WA, but are protected as native wildlife in the NT and the ACT. Dingoes do not occur in Tas and their importation is prohibited.

THE TASMANIAN DEVIL – AUSTRALIAN SPECIES AT GREAT RISK?

The Tasmanian Devil (*Sarcophilus harrisii*) is a carnivorous marsupial found only in Tasmania and is listed as endangered under the EPBC Act. The greatest present threat to the devil is Tasmanian Devil Facial Tumour Disease (DFTD). DFTD is an infectious cancer that forms lesions and lumps on the devil's face and neck, usually resulting in death within three months. The disease is new and has wiped out more than 70% of the devil population in only about 10 years.

Compounding the impact of DFTD is the low genetic diversity of the Tasmanian Devil population. Genetic similarity means that most devils respond to the disease in the same way. The crash in overall population size and isolation of subpopulations is likely to result in more inbreeding and a further reduction in genetic diversity in the wild.

The Save the Tasmanian Devil Program has developed what they call an 'insurance population' of devils, which will be used help restore the natural devil population. The insurance population now consists of 170 individuals held in zoos and wildlife parks in Tasmania and elsewhere in Australia. Devils are being selectively bred to maximise genetic diversity in the insurance population. The race is on to find a cure for DFTD, but scientists also believe that boosting the gene pool will be critical if the species is to survive.

A note of hope has been sounded recently by scientists who have identified a group of devils in north-western Tasmania that are genetically different. Dr Kathy Belov says this information could open the door to the breeding of resistant devils in captivity before releasing them into the wild. However, the long-term aim of the breeding program remains focused on maintaining as much genetic diversity as possible for future generations.

A wild Dingo on the beach of Fraser Island, Australia. Image: iStock

Activities

LOWER PRIMARY – PRIMARY

Whilst it would be inappropriate to introduce terms such as 'genetic diversity' to younger students, there is no reason why they cannot be introduced to its effect in a population of familiar living things.

Examples:

1. In the wild, budgerigars (*Melopsittacus undulatus*) are small green and yellow parrots, with black barring on the back of the head, neck and cheeks as well as a small patch of blue on the cheek. Since its introduction into captivity, the budgerigar has been bred in a variety of colours including white, blue, yellow, mauve, olive and grey. Can you visit a budgerigar breeder or a pet shop where different colours can be seen? If all else fails *http://www.budgieplace.com/colorsguide.html* shows all the current colours that have been found in captive breeding. A teacher reference on budgie genetics is available at *http://www.avianweb.com/budgiemutations.html*

2. Collect several samples of a particular type of flower – nasturtiums are particularly suitable. Students can then note the diversity in flower shape and colour and perhaps speculate about which characteristics would be most attractive to insects for pollination.

MIDDLE SCHOOL

DNA and Endangered Species

In this lesson, students will learn some basics about DNA and genetics and will then research how DNA can be used to study and help endangered animals. They will visit a website with information about specific research projects, and write paragraphs explaining how DNA and genetics research might be used to help an endangered or threatened species. The examples are US based but students may enjoy the variety of interactive and online activities offered. *http://www.nationalgeographic.com/xpeditions/lessons/08/g68/brainpopdna.html*

Biodiversity Basics

This is a US-based site so the animal example used is North American. However, the activities sequence in Activity 1.4 elegantly demonstrates the impact and importance of genetic variability. Download either the 184-page booklet or a single activity from: *http://dnr.state.il.us/education/ilbiodiversitybasics/toc.htm*

UPPER SECONDARY

Genes, the Environment and Natural Selection

The following link has a series of 10 activities related to genes, natural selection, adaptation and populations. The series will provide older students with models that demonstrate the importance of variation in populations with changing environments. Having completed these activities, the final question asks students to relate what they have learned to the likelihood of species with low genetic diversity surviving any pressures on the environment, including climate change. *http://peer.tamu.edu/curriculum_modules/ecosystems/module_1/activity.htm*

The activities can be extended further with:

1. a debate on the merits of preventing species with low genetic diversity from becoming extinct. A starting point for research could be: *http://www.wildlifeextra.com.au/go/news/tasmanian-tigers232.html#cr* or possibly this quote: *Disagreement also exists regarding the ramifications of species loss. People who may be concerned about the fate of the panda or blue whale may feel less sense of loss if an undiscovered species of beetle in the tropical rainforest becomes extinct—a far more likely scenario. In many cases, another species may simply replace the ecological niche or function of a species that became extinct. "Losing a species may be tragic," writes author Mark L. Plummer, "but the result is rarely, if ever, catastrophic." Conservationists retort that the cumulative ramifications of loss of biodiversity may very well damage the resiliency of ecosystems*. From *http://www.enotes.com/biodiversity-article*

2. examination of one or more captive breeding programs in Australia, with an emphasis on the strategies used to ensure maximum genetic diversity in the population. The topic could be introduced via this article: *http://www.australiangeographic.com.au/journal/the-good-fight-captive-breeding-programs.htm* whilst the following document outlines some methods used to safeguard species, including captive breeding programs: *http://www.environment.nsw.gov.au/resources/nature/policyFaunaTranslocation.pdf*

3. expansion of the Tasmanian Devil story by asking students to write a newspaper article explaining the significance of the apparently genetically different devils in NW Tasmania, or a letter explaining why funding for research into this topic is important. *http:www.tassiedevil.com.au* has good information.

The Genetic Basis of Inheritance

If students have prior knowledge of the mechanics of inheritance such as dominant and recessive alleles, multiple alleles and the impact of environmental factors on expression of some genetic characteristics, they will be able to make more informed decisions about the value of conservation practices.

Genetics with an emphasis on humans

http://www.genome.gov/10005911 has many resources to assist teachers with lessons on genes, DNA and inheritance.

http://www.accessexcellence.org/RC/genetics.php also has a series of useful links.

Genetics with an emphasis on plants

http://www.landcareeducation.com.au/resources/downloads/Propagation_from_cuttings.pdf has a detailed lesson plan on taking cuttings. As this is one method used to help save threatened species, it is important for students to realise that all offspring of such a technique are genetically identical. This can lead into a discussion of the comparative importance of this technique for species survival, as it increases numbers but not genetic diversity. The Wollemi Pine and the search for genetic variations in this rare plant are examples of modern research into this issue. *http://www.rbgsyd.nsw.gov.au/plant_info/wollemi_pine*

Recommended Online Resources

AUSTRALIAN

Australian Animals
This unit has been developed for new arrivals to Australia but the information on text types and Australian animals will be useful in all primary schools. *http://www.decs.sa.gov.au/curric/files/links/Australian_Animals_screen.pdf*

Biodiversity Up Close
http://www.rbg.vic.gov.au/__data/assets/pdf_file/0003/6717/Biodiversity_Up_Close_School_Grounds.pdf A 73-page downloadable pdf colour booklet, which relates the 13 activities within it to Victorian syllabus requirements. It begins by defining and describing biodiversity and includes activities for habitat assessment, flora and fauna surveys and future action.

Botanic Gardens Trust NSW
The opening page of this site is a useful first stop for plant identification. *http://www.rbgsyd.nsw.gov.au/plant_info/identifying_plants/plant_names_and_classificatio*n

CSIRO – Interactive Plant Identification Keys
http://www.csiro.au/science/psnv.html

Centre for Plant Biodiversity Research and Australian National Herbarium
http://www.anbg.gov.au/cpbr/ The opening page of this site is packed with links to further information grouped under headings including:

- Research Activities
- Botanical Information
- Other CPBR Activities

There also links to:

- The Australian National Herbarium
- A pdf for download on the Australian Tropical Herbarium in Cairns.
- Botanical databases

Conservation of Australia's biodiversity
http://www.environment.gov.au/biodiversity/ Australian Government Department of the Environment, Water, Heritage and the Arts. A comprehensive information site with many links organised under the headings:

- National framework
- Conservation under the EPBC Act
- Biodiversity initiatives
- Science and research
- Search online – a series of databases

Earth Alive – a hands-on look at biodiversity in school grounds
Earth Alive is a 9-11 week Science and Technology program for stage 3 (Years 5-6) that aims to develop knowledge and understanding of, and care for, ecosystems and biodiversity. The 60-page booklet is a 17MB pdf for download. The link for this download can be found at *http://www.sustainableliving.com.au/knowledge-networks/resources/earth-alive-a-hands-on-look-at-biodiversity-in-school-grounds*

Mallee plants – surviving harsh conditions
http://www.anbg.gov.au/education/programs/mallee.pdf
General notes on the mallee vegetation community, with historical information about its use and abuse, specialised adaptations of mallee plants, and notes on the mallee. The 20-page booklet is designed for an excursion to the Australian National Botanic Gardens but is useful stand-alone material.

Nova – Science in the News
An Australian Academy of Science site. The link below opens to a biodiversity subject heading with a number of further links to information and activities for school students. A printer-friendly version of the entire topic is also available, making this a potentially useful resource away from the Internet and computer *http://www.science.org.au/nova/envir-biodiversity.htm*

Ollie Saves the Planet

This online resource has several subject headings relating to Environmental Education.
http://www.olliesworld.com/planet/aus/info/issue/bio.htm is a comprehensive section with detailed information about biodiversity suitable for middle school students.

Plant and Animal Classification and Identification
This is an 11-page downloadable lesson plan which will be useful for older students.
http://www.acs.edu.au/download/samples/ecotour.pdf

INTERNATIONAL

Biodiversity Basics
Illinois Biodiversity Basics, adapted from the World Wildlife Fund's Windows on the Wild: Biodiversity Basics, is designed to provide ideas for integrating biodiversity into your teaching. The activities are targeted to Grades 5 to 8 but several could be adapted for use at other grade levels. You should be able to find plenty of information to introduce the topic and take students through levels of increasing complexity. Download individual activities or the entire 184-page (5MB) booklet from *http://dnr.state.il.us/education/ilbiodiversitybasics/toc.htm*

The Tree of Life web project
http://tolweb.org/tree/ The ToL web project is a collaborative effort of biologists and nature enthusiasts from around the world. On its more than 10,000 World Wide Web pages is information about biodiversity, the characteristics of different groups of organisms, and their evolutionary history.

Botanic Gardens Conservation International, Canada
http://www.bgci.org/canada/edu_act/ This site has a series of graded garden-based and classroom-based activities and lesson plans for students aged 5-17. They are designed for the Canadian context but many can be adapted for, and will work well in, the Australian environment.

ESSENTIAL ECOLOGY

The Gould League

http://www.gould.edu.au/foodwebs/index.html The purpose of the material online is to complement the Gould League Food webs, Classification and Biodiversity Kits available for purchase from the Gould Online Shop. However, they can be used independently.

Plant and Animal Adaptations

http://www.kidcyber.com.au/ is a comprehensive site for primary-middle school students. It covers biomes, as well as plant and animal adaptations.

http://www.teachers.ash.org.au/jmresources/ausanimallinks/ is a list of links about Australian mammals. There are also links on the front page to sites about Australian birds, reptiles, amphibians and fish.

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