Esperance Education Resource Package

Environmental education package exploring threatened species found on the South Coast of Western Australia

SOUTHCOAST NATURAL RESOURCE MANAGEMENT INC.

Australian Government

National Landcare Programme

EERP

CONTENTS

Esperance Education Resource Package

"Children have always been connected to nature. It is often the adults around them who have lost the link."
Claire Warden (2010)

WHY TEACH OUR CHILDREN AND YOUTH ABOUT THE ENVIRONMENT?

Learning about living things, their homes and other environmental elements is fascinating to children and assists them in building empathy for other living things and the environment in which they are living. Care of the natural world is an essential part of all of our actions for sustainability and addressing the many environmental issues which we are now facing and which our children will face in their lifetimes.

The children of today are the future guardians of Australia, the Earth and all of its unique environments. By building the awareness and knowledge of children, this in turn leads to increased awareness of the issues in the wider community as the children go home to their parents and talk to their neighbours other family members, friends etc. All this talk about the environment, its issues and what can be done about it can inspire further knowledge building and positive actions to preserve our Earth, its systems and its inhabitants now and into the future.

SCOPE

The Esperance Environmental Education Program has been developed by South Coast Natural Resource Management to support an increase in the level of understanding and involvement of the Esperance community in caring for their environment, particularly schools, through teachers and students. The program has a very strong local focus which acknowledges the unique and wonderful environments of Esperance and its surrounding districts.

The development of the program is timely given the present focus on nature pedagogy throughout Western Australia, particularly at a great number of schools across the South Coast. The Esperance Environmental Education Program will provide further opportunities for teachers and students to be in the environment to:

- Build an appreciation for nature and the uniqueness of the Esperance environments,
- Increase their knowledge of nature through the various systems and how they interact,
- Get a dose of nature play with the various activities suggested,
- Increase their desire to live a more sustainable lifestyle.

Within each lesson plans there is a detailed Teacher Background Information section which provides the following information:

- A definition of the topic,
- Why the topic is important,
- Threats impacting on the topic
- The topic in an Australian and Esperance context, and
- What is being done to address the environmental issues.

SEQUENCE

Learning about the environment is an exciting, challenging and rewarding opportunity for students to begin to better understand the connectedness of nature and how we as humans both rely on and can heavily impact on nature.

Each of the lesson plans have been developed to build an understanding and it is strongly recommended that they are presented to the children in the sequence presented in Table 1 if possible. Where it is not possible, individual lessons can be presented to the students in the area of interest to the students and teacher or to compliment other activities and areas of study in the classroom.

Order	Lesson
1.	Biodiversity
2.	Threatened Species
3.	Veg and Weeds
4.	Dieback
5.	Catchment Health
6.	Water quality
7.	Macroinvertebrates
8.	Birds
9.	Climate Change

PHASES OF LEARNING

In order to provide an overview of the key environmental issues relevant to the Esperance region, the suggested activities have been prepared with students in Years 3 to 6 in mind. It is believed that individual teachers and schools will be able to adapt the activities to suit either an early learning environment or middle school age group. Further reading has been provided to assist with this and a digital media section has been included in many of the lesson plans.

Emphasis has been placed on ensuring that the teacher background material has been very well researched and referenced so that individual teacher knowledge is supported to enable the delivery of the program. The teacher backgrounds provide up to date information on the environmental issues included. Sometimes the global nature of some of the topics covered in the program can leave the students wondering 'what has this got to do with me?' Local content is provided to support the engagement of the students as local residents themselves.

FIELD TRIPS

For the students to get a gauge on the health of the local environments in Esperance, with respect to the range of topics covered in the Esperance Environmental Education Program, it would be advantageous if the field trips were located at no more than 2 separate sites. Lake Warden is a suitable location because of its importance to the biodiversity both in the Esperance region and globally as a Ramsar listed wetland. It is also relatively easy to access and has low travelling times.

Local staff at South Coast Natural Resource Management or the Department of Parks and Wildlife could suggest other potential field trip sties.

WORD WALL

During the delivery of the Esperance Environmental Education program, the use of a "Word Wall" (with images for early learners) would be advantageous to build the students environmental science vocabulary and reinforce literacy objectives.

CELEBRATING THE COMPLETION OF THE PROGRAM – A SUGGESTION

As a final activity for the Esperance Environmental Education Program in recognition of the importance of biodiversity, the school may entertain the idea of becoming involved in a revegetation or conservation project in the Esperance region. On-ground works are continually occurring in the Esperance region to conserve coastal areas and improve catchment health and there is always opportunity for students and the youth to be involved.

ABOUT SOUTH COAST NRM

South Coast Natural Resource Management is a not-for-profit community-based organisation delivering projects that preserve, protect and improve the natural resources of the South Coast region of Western Australia. South Coast NRM works with a range of partners and stakeholders from individual landholders through to the Australian Government on the key areas of water, land, coastal and marine, cultural and biodiversity South Coast NRM are one of 56 Australian NRM groups committed to achieving positive social and economic outcomes and the sustainable long-term management of the natural environment. There are six other NRM groups in Western Australia.

For more information visit: http://southcoastnrm.com.au/

ABOUT THE AUTHORS

Chrissy Kerin and Johanna Tomlinson are both Environmental Science graduates from Murdoch University. Both Chrissy and Johanna live in regional Western Australia on working farms and have worked in the agricultural and natural resource management industries for over 15 years. As parents of school aged children now, both Chrissy and Johanna are passionate about sharing their knowledge of the environment in a practical way to assist the next generation in understanding, developing a love of and caring for our planet.

FURTHER INFORMATION

If you require more information about the Esperance Environmental Education Program, please contact:

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BIODIVERSITY

1. OVERVIEW

Students will gain an understanding of biodiversity, why it is important, how all living things are interconnected, that humans are a part of nature (and not just living in it), that humans can impact on biodiversity and that there are many things being done to conserve biodiversity in Esperance and across Australia and the wider international environment.

2. LINKS TO THE AUSTRALIAN CURRICULUM

STRAND	SUB-STRAND / KEY ORGANISING IDEAS
ENGLISH Language	Language variation and change Text structure and organization
Literature	Literature and context
Literacy	Interacting with others Creating texts
SCIENCE Science understanding	Biological sciences
Science inquiry skills	Questioning and predicting Planning and conducting Processing and analysing data and information Communicating Evaluating
SUSTAINABILITY	Systems World views Futures

3. OBJECTIVES

Students will:

- Observe an individual species and the part it has in a local ecosystem.
- Understand biodiversity, species, habitats, ecosystems and the importance of the interconnectedness of all living things.
- Research a local critically endangered endemic bird species and be aware of actions being taken locally to support the biodiversity.

TOPICS
Biodiversity
Ecosystem
Food Web
Habitats

PHASES OF LEARNING
3-6, 7-9

SITE (LOCATION)
classroom
local environment of your choice (e.g. wetland, bushland, etc).

ACTIVITIES
1. Excursion (2 to 3 hrs)
2. In class (1.5 Hrs)

MATERIALS
- Web of life student worksheet
- Clip boards
- Note paper
- Pencils
- Ipad and/ or camera for image capture
- Hat and sunscreen and other in-field requirements
- Large floor or outdoor area to map out the town/ ecosystem.
- 2-3 pieces of A5 paper per student
- Blu-Tack or rocks and sticks
- Pencils/ crayons (inside) and/ or chalk (outside)

STUDENT WORKSHEET
Web of Life Student Worksheet

4. TEACHER BACKGROUND INFORMATION

4.1 What is biodiversity?

Our world is brimming with life! Biological diversity – or biodiversity – is the term used to describe the variety of all living things and how they interact, the web of life on Earth. Biodiversity includes genetic diversity, species diversity, ecosystem diversity and their associated evolutionary and ecological processes.

There are literally millions of species of plants and animals in the world – there are different birds, mammals, amphibians, reptiles, insects, molluscs, worms, fish, trees, shrubs, grasses, ferns, conifers – the list goes on. Most living things are either a plant or animal but some are neither, such as bacteria and viruses (Sneddon and Pettit, 2016). New species of plants and animals are constantly being discovered and scientists estimate there are millions more left to discover. The most commonly discovered new species are typically insects, a type of animal which has a high degree of biodiversity. Newly discovered mammal species are rare, but they do occur, typically in remote places that haven't been well studied previously (Live Science, 2016).

So much life thrives on Earth because of its air, land, freshwater and marine environments and the habitats which they provide. Oceans, coral reefs, rainforests, shorelines, mangroves, wetlands, grasslands, mountains are some of the great variety of environments where living things can find what they need to survive and reproduce. All plants and animals have amazing features and characteristics which they have developed (and continue to develop) over time through evolutionary processes. These adaptations enable them to find food, protect themselves and reproduce in a wide range of environments (Sneddon and Pettit, 2016).

In nature, plants and animals are connected through the food webs that they are a part of. They also interact with the environment around them as they meet their needs for water, shelter and space. In a healthy ecosystem there is competition and predation, as well as cooperation and dependency between species as they share land and water.

An important aspect of biodiversity that is not always apparent is the interconnectedness between all species, in other words the way in which they depend on one another for survival. One way in which this can be presented is by food chains and webs (NSW National Parks and Wildlife Service, 2003)

"The health and activity of each species contributes to the dynamic balance within its ecosystem."

4.2 Why is biodiversity important?

"Nature doesn't need people. People need nature." Conservation International

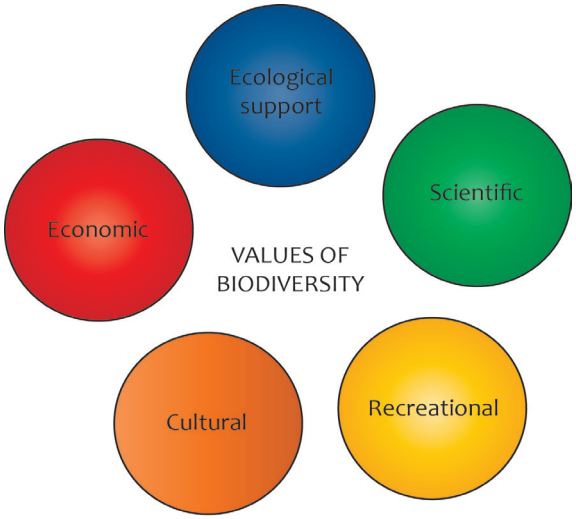
Biodiversity is vital for supporting all life on Earth. It provides all of our food and many industrial products and medicines. Biodiversity ensures clean air, water and fertile soils, it provides opportunities for recreation, tourism, scientific research and education, and it is a source of cultural identity for many Australians. Understanding biodiversity, and why it matters, is assisted by comprehending the range of distinctive values that individuals and societies may assign to the living world and the ecosystems that it comprises (CSIRO, 2014).

The CSIRO discusses five primary values of biodiversity:

1. **Ecological support**: Biodiversity provides humans with the healthy, functioning ecosystems that make up the Earth, without which our societies could not exist. Nature delivers to us a supply of oxygen, clean water, pollination of plants, pest control, and so on. As understanding and evidence about the intercon nectedness of the natural and human worlds has grown over the past century, many have come to believe that protection of the web of life is vital to our own interests, and biodiversity is a convenient expression of that value system. In fact, the concept of 'ecosystem services' – the multitude of resources

and processes that are supplied by biodiversity to human beings – grows out of this value. Such a value system is shared by almost all human beings in at least some degree (CSIRO, 2014)

Figure 1: VALUES OF BIODIVERSITY



2. **Economic**: The natural world provides humans with raw materials for direct consumption and production, and from which to make money. We harvest fish and timber, for example, and make from them food and goods with utilitarian value in the marketplace. This category expresses the material use of nature by humans for direct benefit. These benefits – and the economic value system that lies behind them – are held especially dear by many whose livelihoods bring them close to the natural world, such as farmers, fishers, timber workers, bee-keepers, and so on (CSIRO, 2014).

3. **Scientific**: this value highlights the worth of systematic ecological data in helping us to understand the natural world, its origins, and the place of the human species within it. Scientists are likely to highlight the excitement of uncovering genetic diversity, for example, or cataloguing the strange creatures of the deep-sea trenches, or understanding how vegetation patterns are influenced by fire. While economic benefit may well accrue from scientific understanding, the motivation of the scientific value system is primarily intellectual. Understanding our environment and biodiversity further develops our understanding particularly of the ecological support it provides for Earth (CSIRO, 2014).

4. **Cultural**: the cultural values of biodiversity are realised through the expression of identity or through spirituality or an aesthetic appreciation. Indigenous peoples in Australia express cultural values especially strongly and in an unusually intimate fashion, through symbolic connections to animals and plants, that are believed also to be ancestral beings. Spiritual values are a subset of such connections, an opportunity to explore questions about the meaning of the universe through contemplation of biodiversity. The splendour of nature also provides aesthetic values simply through the appreciation of the non-human world. Artists are frequently the major bearers of this value system with aesthetic values of biodiversity being appreciated more broadly across society, and often by direct individual absorption in a natural context as well as by reflection in art galleries or in the words of poems and songs. Finally, education makes up another aspect of cultural values, providing the basis for discussion about how to live sustainably on planet Earth (CSIRO, 2014).

5. **Recreational**: The world over, people enjoy being in and interacting with the natural environment. There are a multitude of activities for individuals, families, groups and communities to enjoy the wonder of the Earths biodiversity, particularly here in Australia. A large proportion of the tourism industry generates an economic gain from the recreational values which we hold for biodiversity.

If we consider the services that optimum biodiversity provides and consider the value of each of these, it very

quickly becomes apparent how important it is to conserve biodiversity at a local, regional, national and global scale.

4.3 Threats to biodiversity

Biodiversity is not static; it is constantly changing. It can be increased by genetic change and evolutionary processes, and it can be reduced by threats which lead to population decline and extinction. All environments naturally change over time, but the disturbance and destruction of natural habitats and the unsustainable use of natural resources is putting individual species and the heathy ecosystems we all rely on and enjoy, at risk (Sneddon and Pettit, 2016). Biodiversity in Australia is currently declining because of the impacts of a range of threats.

Scientific progress is being made in understanding the likely consequences of declining ecological life-support. We now know the following general principles:

- Biodiversity loss can reduce the efficiency with which ecosystems acquire resources, produce biomass, and decompose it to recycle nutrients.
- Maintenance of biodiversity allows ecosystems both to keep working in the face of ongoing change and to recover functions more readily after a shock.
- The impact of a decline in biodiversity on the ecosystem accelerates as the loss increases.
- Diverse communities may be more productive because species differ in the way they capture energy and nutrients, so leading to a potentially greater collective uptake.
- Loss of diversity at multiple levels within a food chain (e.g. from grasses through grazing animals to their predators) can influence ecosystems more than loss within just one level.
- Effects of extinction range from undetectable (for species having small roles in ecosystem functions) to profound (for those that dominate the working of the ecosystem) (CSIRO, 2014).

Over the last 200 years, Australia has suffered the largest documented decline in biodiversity of any continent (Department of Environment, 2016a). Despite efforts to manage threats and pressures to biodiversity in Australia, it is still in decline. Since European settlement, more than 50 species of Australian animals and over 60 species of Australian plants are known to have become extinct (Department of Environment, 2016b). More than 1,700 species and ecological communities are known to be threatened and at risk of extinction currently in Australia (Department of Environment, 2016c).

The main threats to the biodiversity in Australia and the Esperance region (also known as threatening processes) are:

- reduction, fragmentation and degradation of habitat through clearing,
- salinity and altered hydrological regimes (the aquatic environment and water flows),
- altered ecological processes (ie: adoption of European farming practices),
- invasive species,
- plant diseases (ie: Phytophthora dieback),
- climate change resulting from unsustainable use of natural resources, and
- inappropriate fire regimes.

4.4 Biodiversity in Australia and the Esperance Region

Australia was once part of the great southern landmass Gondwana, which also included South America, Africa, India and Antarctica. Gondwana began to break up around 180 million years ago, with Australia eventually splitting from Antarctica about 45 million years ago. As a result Australia's biodiversity has developed largely in isolation over many millions of years (Gondwana Link, 2016). Evolution, driven by continental isolation, varied environments, climate change and species adaptations, has resulted in Australia being home to large numbers of species that occur nowhere else in the world, endemic species. Over 80% of our plants and mammals, and 45% of our birds only live here (WWF, 2016 and Department of Environment, 2016b).

The uniqueness and value of biodiversity in Australia on a global scale has been identified, researched, documented and acknowledged. Australia is one of seventeen countries described as being 'megadiverse'. This group of countries has less than 10% of the global surface, but support more than 70% of the biological diversity on earth. (WWF, 2016 and Department of Environment, 2016b).

Scientists have further identified 34 'biodiversity hotspots' in the world which are considered to be of international significance and support a combination of high species diversity, high numbers of endemic species and high levels of threat to biodiversity. The South West Botanical Province of WA (defined by a line from Shark Bay to Israelite Bay as shown in figure 1) is one of these 34 'biodiversity hotspots'. Up until recently it was the only identified 'biodiversity hotspot' in Australia. However, there is emerging documentation to support a 35th hotspot (Australia's second) in the north eastern Australia rainforests (coastal forests from Sydney to Cairns).

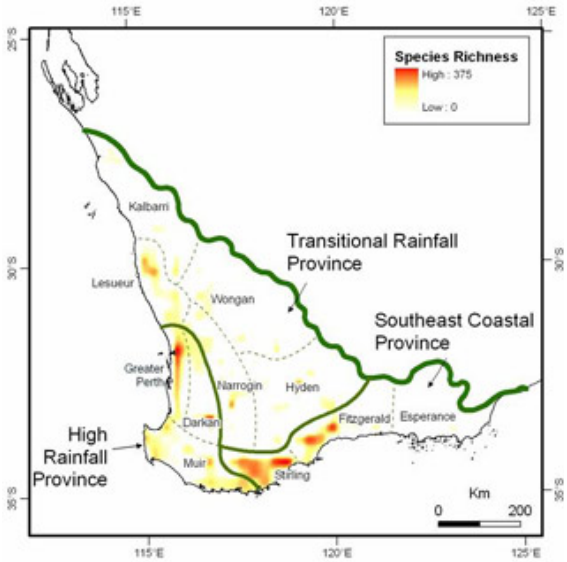


Figure 1: South West Botanical Province of WA, an identified 'biodiversity hotspot' of global significance (Source: http://www.gondwanalink.org/natwonders/biohotspot.aspx)

The South Coast natural resource management region occupies the south eastern part of the South West Botanical Province and contributes significantly to its biodiversity values. In the Esperance sub-regions of the South Coast (the eastern most section of the biodiversity hotspot area), there are many rare and endemic plant and animal (flora and fauna) species. It contains a suite of coastal nature reserves and national parks including Jerdacuttup Lakes and Lake Shaster nature reserves and the Stokes, Cape le Grande, and Cape Arid national parks. Cape Arid is one of only two remaining locations in which the Western Ground Parrot can be found (South Coast NRM, 2011).

Esperance provides key habitat for Carnaby's Black Cockatoo and is home to the internationally significant Lake Gore and Lake Warden systems, which are both listed as wetlands of international significance under the Ramsar Convention. These systems support thousands of rare water birds including, the Hooded Plover, Rechereché Cape Barren Goose and Bandid Stilt (South Coast NRM, 2011).

In the northern reaches of Esperance there are again many rare flora and fauna species as well as threatened ecological communities within the Lake Tay and the Peak Charles systems (South Coast NRM, 2011). Esperance also touches the Great Western Woodland which is significant because it is the largest remaining tract of Mediterranean –climate woodland on Earth (CSIRO, 2016).

4.5 What is being done to address biodiversity decline?

Lost biodiversity can never be fully recovered, but through conservation efforts we can help to ensure that species are able to persist and to restore the capacity of ecosystems to adapt to changes and disturbances-

in other words, to build ecological resilience.

Across society (at the local, regional, state, national and international levels) there are a range of efforts being made to address declining biodiversity. The Department of Environment (Commonwealth of Australia, 2010) categorises all works to preserve and assist Australian biodiversity as follows:

1. **Engaging all Australians:** Getting more Australians involved in conservation and understanding biodiversity and its high value is critical. Mainstreaming biodiversity means integrating biodiversity into decision making so that it becomes everyone's business and is part of every relevant transaction, cost and decision. Indigenous peoples play a significant role in biodiversity conservation in Australia. Not only do they hold title over a large and increasing proportion of Australia's lands and waters, they are also the guardians of traditional ecological and cultural knowledge of Australia's natural environments. Increasing Indigenous engagement through employment, partnership and participation and promoting the two-way transfer of knowledge will lead to both increased opportunities for Indigenous peoples and improved outcomes for biodiversity (Department of Environment, 2016a). Enhancing strategic investments and partnerships are key priorities across Australia.
2. **Building ecosystem resilience:** Biodiversity is best conserved by protecting existing natural habitats. Protecting biodiversity, maintaining and re-establishing ecosystem functions and reducing threats to biodiversity are key priorities to build ecosystem resilience.
3. **Getting measurable results:** Improving and sharing knowledge through good science and delivering conservation initiatives efficiently are important. Coupled with actions, is the need for robust research, monitoring and evaluation of our species and ecosystems and the functions they provide. This data lets us assess if stabilisation and improvements are being achieved through actions.

Various state, national and international legislation and agreements exist aimed at conserving biodiversity. Some examples of this are:

- IUCN International Convention on Biological Diversity 1992,
- Convention on the conservation of Migratory Species of Wild Animals 1979,
- Agreement between the Government of Australia and the Government of the Peoples Republic of China for the Protection of Migratory Birds and their environment.
- Ramsar Convention (an agreement to protect important wetlands).
- *Environmental Protection and Biodiversity Conservation Act 1999*
- National Strategy for the Conservation of Australia's Biological Diversity.
- *Wildlife Conservation Act 1950.*

At a local level there are a number of individuals, community groups, industry bodies and government agencies working to improve the sustainability of the regions industries (particularly agriculture) and to conserve the biodiversity of the Esperance area, including:

- South Coast Natural Resource Management: http://southcoastnrm.com.au/
- Esperance Regional Forum: http://esperanceregionalforum.org.au/
- South East Premium Wheat Growers Association: http://www.sepwa.org.au/
- Gondwana Link: http://www.gondwanalink.org/
- Local Landcare and catchment groups.
- Farmers.

SUGGESTED ACTIVITIES

5.1 ACTIVITY ONE: A Species in its Ecosystem
In-field session. Allow 2-3 hours (account for travel)

Overview:

Students will observe an individual species in its habitat and identify the part it has in that particular

ecosystems web of life. Students will also observe the wider ecosystem and how that individual species fits within that ecosystem.

Teacher Preparation:

- Read Teacher Background Information in Biodiversity lesson plan.
- Make copies of the Web of Life Student Worksheet (A3 would be suitable and provide enough space) (Appendix 1).
- Plan for excursion (ie: Lake Warden).
- Be aware of the environment where the excursion will take place and the diversity of life there in order to be able to assist students in selecting a species to observe and investigate and to be able to lead discussion on the ecosystem the species are living within.

Required Resources:

- Web of Life Student Worksheet
- Clip boards
- Note paper
- Pencils
- iPad and/ or camera for image capture
- Hat and sunscreen and other in-field requirements

Procedures:

1. Take students to a local wetland or natural bush setting (Lake Warden is easily accessible. Students should be informed of its importance as a RAMSAR wetland because the biodiversity provides habitat for thousands of rare water birds including, the Hooded Plover, Rechereché Cape Barren Goose and Bandid Stilt).
2. Introduce key words and concepts and relate to students in more familiar terms:
   - Biodiversity = life on Earth, web of life.
   - Species = animals and plants.
   - Habitat = is a home.
   - Ecosystems = is like a town.
3. Have students find a quiet place to sit for a few minutes (suggest 2 minutes) and observe the life (the biodiversity) around them.
4. Hand out Web of Life Student Worksheet. Ask the students to choose a plant and an animal in the environment that they thought was the most interesting or noticeable during that quiet time. Get the students to individually go and further observe that animal or plant (as close as they can safely without disturbing it) and have them complete the worksheet.
5. As a class, discuss and share back.
6. Go for a walk around the area (that ecosystem), record the dimensions of the area and discuss the biodiversity in the area, the different species, different habitats etc. Ask the students to record the different plants and animals they see. If unsure of names, the students can capture an image of the plant or animal for identification later.
7. As a class reflect on:
   - How many native plants and animals were seen?
   - How the species are all connected in their ecosystem.
   - What things can you see that might threaten the species and the wider ecosystem?
   - What human activities could impact on the biodiversity of the environment?

5.2 ACTIVITY TWO: Habitats, ecosystems and the importance of biodiversity.
In class session. Allow 1.5 hours.

Overview:

This activity (adapted from Papps and Thompson, 2003) uses human settlement as an analogy to introduce the concept of habitats and ecosystems. In this case, a home is a habitat and a town is like an ecosystem, that is, it is made up of lots of habitats and organisms that rely on interaction with one another for survival.

Lesson Output:

Students will make a large 'mud-map' of their individual homes (habitats) and surrounding area (ecosystem) and the different services and relationships that exist within that ecosystem.

Teacher Preparation:

- Read Teacher Background Information in Biodiversity lesson plan.
- Prepare to lead a discussion on habitats, ecosystems and the importance of biodiversity.
- Adequate floor area for activity.

Required Resources:

- Large floor area to map out the town/ ecosystem. As an inside activity a number of large sheets of paper could be laid out. As an outside activity an area of concrete or bitumen would be suitable.
- 2-3 pieces of A5 paper per student
- Blu-Tack or rocks and sticks
- Pencils/ crayons (inside) and/ or chalk (outside)

Procedures:

1. Introduce key words and concepts and relate to students in more familiar terms:
   a. Biodiversity = life on Earth.
   b.Species = animals and plants.
   c. Habitat = is a home.
   d. Ecosystems = is like a town.
2. Ask students to close their eyes and visualise their home (the size of the rooms, the colour). Then get each student to draw their home on a piece of A5 paper and label it "Sally's Habitat" (encourage them to use their name so the students can relate later).
3. Ask students why their home (their habitat) is so important to them. Emphasise that people in a town need their habitat to survive, just like animals and plants do in natural areas.
4. On large floor area arrange the habitats as a town is organised (the ecosystem) and secure (Blu-Tack, rocks or sticks depending on location).
5. Discuss how the habitats are a part of the larger town (the ecosystem) and that they are interconnected and rely on each other. Discuss what other features should be added to the town to make it complete ie: roads, parks, schools, shopping centres, creeks, bus stops, plants and animals.
6. Get students to draw in other parts of the ecosystem, possibly splitting them up into groups to work on a section of the ecosystem mud-map.
7. Use the following discussion to help establish the analogy of a town operating like a natural ecosystem:
   - The habitats provide shelter and a safe place to live. What types of habitats might animals use?
   - People move between habitats. What animals move between habitats?
   - People move out of their habitat to find food. Does this happen in the natural environment?
   - Some people have jobs that help other people. How do some plants and animals support other species?
   - Some people have jobs that help keep the town healthy. How do plants and animals also help to keep the environment healthy?

8. Take an image of the ecosystem. Discuss and reflect on,
   - How do people live similarly to plants and animals?
   - Why could we call this the Web of Life?

SUGGESTED FURTHER READING:

Australia's Biodiversity Conservation Strategy at: http://www.environment.gov.au/biodiversity/publications/australias-biodiversity-conservation-strategy

Department of Parks and Wildlife: https://www.dpaw.wa.gov.au/

National Geographic Education: http://nationalgeographic.org/encyclopedia/biodiversity/

Perth Zoo: http://perthzoo.wa.gov.au/animals-plants/australia/

World Wide Fund for Nature http://www.wwf.org.au/

DIGITAL MEDIA:

Title and Description	At:
"Why is biodiversity so important?" TED-Ed A 4.18min You Tube video explaining how an environment rich in biodiversity (such as the Amazon Rainforest with its great diversity of ecosystems, species and genetics) has the resilience to withstand and recover from change and conversely how a coral reef ecosystem which is also greatly biodiverse but is less resilient due to its dependence on the corals (a keystone species) health.	https://www.youtube.com/watch?v=GK_vRtHJZu4
"What is biodiversity and why is it important?" CSIRO A 7.52min video which presents the values that humans obtain from biodiversity and the role we will need to play in shaping its future.	https://www.youtube.com/watch?v=7tgNamjTRkk
"Remote and Rugged - Part 1", South Coast NRM. A 25.00min You Tube video exploring the natural history of the South Coast region of Western Australia and its relationship with Aboriginal people and early European explorers. It also looks at the footprint modern humans are leaving on the landscape and the important conservation work being undertaken to preserve this area for the future. Also available in DVD format from South Coast NRM, Esperance Office.	https://www.youtube.com/watch?v=vQ_wKiqVWoI
"Nature is Speaking – Julia Roberts is Mother Nature" A 1.58 minute Conservation International production.	https://www.youtube.com/watch?v=WmVLcj-XKnM

VOCABULARY

Biodiversity: the variety of all living things on earth

Critically endangered: a species facing an extremely high risk of extinction in the wild. It is the highest classification for threatened species.

Ecosystem: a community of plants and animals interacting with one another and the surrounding environment.

Endemic: a species found only in one particular area.

Habitat: the place where a plant or animal naturally lives or grows.

Threatened species: A species recognised and listed as a species that is under threat from extinction. See Threatened Species lesson plan.

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Appendix 1: Web Of Life
Student Worksheet

What other plants and animals does your plant provide shelter to?

What does it needs to survive?

YOUR PLANT…
Draw it, name it, describe it:

What is your plant a food source for?

What other plants or animals is your plant threatened by?

Appendix 1: Web Of Life Student Worksheet

What does your animal eat?

Where does your animal live? Describe its habitat.

YOUR ANIMAL…
Draw it, name it, describe it:

What is your animal eaten by?

What other plants and animals does your animal need to survive?

THREATENED SPECIES

1. OVERVIEW

There are a number of threatened flora (plant) and fauna (animal) species, as well as threatened ecological communities in the Esperance region. This lesson plan allows students to spend time with an expert working in the conservation field where they can develop an understanding of what a threatened species is. Students will then develop a greater knowledge and understanding of a selected number of individual threatened species and what work is being done to assist in their conservation and recovery.

2. LINKS TO AUSTRALIAN CURRICULUM

STRAND	SUB-STRAND / KEY ORGANISING IDEAS
ENGLISH Literacy	Creating texts Interpreting, analysing, evaluating Texts in context
Literature	Creating literature
SCIENCE Science as a human endeavour	Use and influence of science
Science inquiry skills	Communicating Evaluating Planning and conducting Processing and analysing data and information
Science understanding	Biological sciences Earth and space sciences

TOPICS
Threatened species
Conservation
Species ecology

PHASES OF LEARNING
3-6, 7-9

SITE (LOCATION)
Classroom
Local environment

ACTIVITIES
1. In field/in class (1 – 2 hrs)
2. In class (1.5 - 2 hrs)

MATERIALS
- Worksheets
- Pens, pencils.
- Resources as required by visitor.
- Computers/ tablets with internet access (potentially with printing access or data storage and retrieval).
- Library resources.
- Note pad and pens/ pencils.

STUDENT WORKSHEET
Talking with the Experts: Student Report Worksheet

3. OBJECTIVES

Students will:
- Learn broadly about the threatened species in the Esperance region by interacting with a conservation expert working (or volunteering) in the Esperance region.
- Gain a more detailed understanding of the identification, behaviour, distribution, habitat, threats and actions being taken to assist in species conservation and recovery for a selected number of the threatened species in the Esperance region.

4. TEACHER BACKGROUND INFORMATION

4.1 What is a threatened species?

Extinction is forever.

A threatened species is a species of plant or animal that is facing threats to their survival and may be at risk of extinction (Department of Environment, 2016a). As well as individual threatened plant or animal species, an entire ecological community may be classified as threatened, that is, the natural composition and function of the ecological community has been significantly depleted across its full range (Department of Environment, 2016b).

In Australia, threatened fauna, flora and ecological communities may be nominated and listed under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. In order to determine if a species or ecological community is eligible for listing as threatened in one of the categories under the EPBC Act, a rigorous scientific assessment of its threat status is undertaken. The EPBC Act provides for the following rankings:

- **Extinct**: No reasonable doubt that the last individual of that species has died.
- **Extinct in the wild**: When a species is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range of that species.
- **Critically Endangered**: A species facing an *extremely* high risk of extinction in the wild.
- **Endangered**: A species considered to be facing a *very* high risk of extinction in the wild.
- **Vulnerable**: A species considered to be facing a *high* risk of extinction in the wild.

In Western Australia, the Wildlife Conservation Act 1950 provides for the listing of threatened native plants and threatened native animals that need to be specially protected because they are under identifiable threat of extinction, are rare, or otherwise in need of special protection. The State Minister for Environment may list an ecological community as being threatened if it is presumed to be, or is at risk of becoming, totally destroyed (DPaW, 2016).

Both the federal and state legislations are guided and have adapted rankings and assessment processes for threatened species from the International Union for the Conservation of Nature (IUCN) Red List Categories and Criteria. The IUCN Red List Categories and Criteria are an internationally accepted system developed for classifying the extinction risk for a wide range of species (IUCN, 2016, Department of Environment, 2016a and DPaW, 2016).

Ecosystems near large population centres and on prime agricultural land have experienced the greatest declines; hence, most endangered species occur along the eastern coastline and in south-eastern and south-western Australia.

4.2 Why is it important to be aware of threatened species?

Our world is brimming with life! Biological diversity – or biodiversity – is the term used to describe the variety of all living things and how they interact, the web of life on Earth. Species and ecological community health and well being are indications of biodiversity, and hence the health of our planet.

Recall from the Biodiversity lesson plan Teacher Background Information that Australia's biodiversity is in decline. This is evidenced by extinctions and a very high number of species and ecological communities being classified as threatened.

Being aware of threatened species and threatened ecological communities is imperative as it informs us and provides a gauge as to the health of our ecosystems which we as humans (as well as all other living things) rely on for ecological support, our economies, scientific knowledge and understanding of our planet, as well as cultural and recreational values. Having such high rates of threatened species and threatened ecological

communities is a clear indication that the health of the environment is being severely impacted and that conservation works and a move to more sustainable actions.

4.3 What threats are impacting on species?

The main reason that animals, plants and ecological communities become threatened or extinct is because of habitat loss, disruption and change.

Humans have great power to change and destroy habitats and so reduce the chances of species surviving. Species and their habitats are affected when vegetation is cleared for uses such as agriculture, forestry, mines, suburbs and roads; when rivers are dammed to store water; or when swamps are drained for developments. Introduced animals such as foxes, rabbits, and feral animals can also cause population decreases in native species that can lead to them becoming threatened.

Recall from the Biodiversity lesson plan Teacher Background Information that the main threats to the biodiversity in Australia and the Esperance region are:

- reduction, fragmentation and degradation of habitat through clearing,
- salinity and altered hydrological regimes (the aquatic environment and water flows),
- altered ecological processes (ie: adoption of European farming practices),
- invasive species,
- plant diseases (ie: Phytophthora dieback),
- climate change resulting from unsustainable use of natural resources, and
- inappropriate fire regimes.

4.4 Threatened Species in Australia and the Esperance Region

Since European settlement, more than 50 species of Australian animals and over 60 species of Australian plants are known to have become extinct (Department of Environment, 2016b). Over one third of all the mammal species that have become extinct worldwide in the past 200 years have been lost from Australia, meaning Australia has the highest rate of mammal extinction in the world (The Nature Conservancy, 2016).

In Australia there are currently more than 1,700 species and ecological communities known to be threatened and at risk of extinction (Department of Environment, 2016a).

Within the South Coast region, there are 121 taxa (a group of one or more populations of an organism or organisms seen by taxonomists to form a unit) of flora (plants) currently at risk of extinction or range reduction and listed as threatened flora.

- 38 South Coast threatened flora are regarded as critically endangered,
- 34 are in the endangered category, and
- 49 are listed as vulnerable.

These represent 30 per cent of the Western Australia's threatened flora. A further 793 taxa are listed as priority species which require monitoring or more investigation to determine their conservation status (SCNRM, 2016).

The proportion of threatened flora populations found entirely within protected national parks and nature reserves has remained fairly stable since 2004, while those occurring outside conservation areas have risen by 5.7 per cent (SCNRM, 2016). These populations account for 30 per cent of the total South Coast threatened flora and may be at significantly greater risk of threatening processes than those within the conservation estate. Twenty-three regional flora species have increased their threatened status since 2004, while nine have had their status reduced (SCNRM, 2016)

In terms of fauna, about 414 species of native vertebrate animals, including 42 mammals, 300 birds, 70 reptiles, 22 frogs and 10 fish are found within the South Coast region across habitats according to rainfall, vegetation and landform. These numbers do not include the multitudes of invertebrate species such as insects, spiders

and crustaceans. Twelve species of mammals and two bird sub-species are now presumed extinct on the South Coast since European settlement. The South Coast's 59 threatened terrestrial and marine fauna species represent 28 per cent of the state's total of 209 (SCNRM, 2016).

Nearly three-quarters of the Western Australia's threatened terrestrial birds and 29 per cent of threatened terrestrial mammals occur on the South Coast (SCNRM, 2016).

Key threatened animal species in the Esperance region include: the Carnaby's Black Cockatoo (classified as Endangered), the Hooded Plover (classified as Critically Endangered), the Western Ground Parrot (classified as Critically Endangered) and the Chuditch (classified as Vulnerable) . A key threatened plant species in the Esperance region is *Lambertia echinata subsp: echinata*, the Prickly Honeysuckle (classified as Endangered). Esperance is also home to the threatened ecological community of 'Proteaceae Dominated Kwongkan Shrublands'.

4.5 What is being done about Threatened Species?

Humans are becoming increasingly aware of the threats to biodiversity and the threatening processes impacting on species and ecological community survival. There are a number of actions which are being taken locally, regionally, at a stage and federal level in Australia and internationally to ensure the protection of our native species and more broadly, the planets biodiversity.

4.6 Legislation:

Within Australia the Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act) is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places. The EPBC Act protects Australia's native species and ecological communities by providing for:

- identification and listing of species and ecological communities as threatened
- development of conservation advice and recovery plans for listed species and ecological communities
- development of a register of critical habitat
- recognition of key threatening processes
- where appropriate, reducing the impacts of these processes through threat abatement plans and non-statutory threat abatement advices (Department of Environment, 2016a).

In Western Australia we have the Wildlife Conservation Act 1950 which provides for the conservation and legal protection of flora and fauna. Under this piece of legislation threatened flora and fauna are listed and protected. The Department of Parks and Wildlife, with the help of community groups and local people, develops and implements recovery plans and interim recovery plans for threatened species and ecological communities. The Department of Parks and Wildlife also prepares wildlife management programs for plants listed as threatened or that the department knows little about (priority flora) (DPaW, 2016). Within Western Australia there is also the *Environmental Protection Act 1986* which provides for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment.

4.7 Growing knowledge through science, monitoring and evaluation:

While baseline information and understanding of ecological functions and processes has increased significantly in recent years, some systems are still poorly understood, particularly in the east of the region, which includes Esperance (SCNRM, 2016). A range of bodies are working to further increase the pool of knowledge about threatened species. At a government level for instance, the Threatened Species Scientific Committee is an independent committee of eminent conservation scientists that provides the Minister for the Environment with advice on matters relating to listing, conservation and recovery of threatened species and ecological communities, and listing and abatement of key threatening processes.

Monitoring and evaluation programs are vital to ensure we are continually aware of a range of factors including: species (both native and feral/ weed) populations, ecosystem health, threatening processes and their impacts. The data that results from monitoring and evaluating the range of environmental parameters feeds back into the building the knowledge through science to inform communities, industry, government and decision makers about progress and future required research, protection strategies and on-ground works.

4.8 Education, awareness raising and communication:

Education, awareness raising and communication are critical activities being carried in order to develop a greater awareness and knowledge by individuals, communities, industry groups and decision makers about the threatening processes which impact on species and ecological community health and survival. This Esperance Environmental Education Program is one example of many environmental programs across Australia which seeks to raise the awareness and understanding of school aged children and youth about environmental issues as they are the next generation who will bear the responsibility of caring for our planet.

Of note with regard to awareness raising activities is National Threatened Species Day is held on 7 September each year. National Threatened Species Day was first held in 1996 to commemorate the death of the last Tasmanian Tiger in captivity in 1936. The concept was developed by the Threatened Species Network, a community based programme of the World Wide Fund for Nature and the Australian Government as a way to showcase Australian threatened species (Australian Government, 2006).

4.9 Large-scale on-ground actions

In terms of on-ground actions, to conserve a species we start with conserving their habitat (The Nature Conservancy, 2016). Prioritisation of effort and funding is required due to finite funding and effort.

Local groups such as the Esperance Regional Forum and South Coast NRM work with local individuals and communities to develop projects and access funding to undertake on-ground activities to assist in the conservation and recovery of threatened species. On-ground actions to conserve habitats include:

- Fencing and protection of remnant vegetation,
- Revegetation to enhance and connect remnant vegetation,
- Wide-scale rabbit and fox control,
- Weed control activities, and
- Adoption of improved farming practices to reduce negative impacts on the environment and maintain and improve catchment health (see Catchment Health Lesson Plan Teacher Background Information).

Wider landscape scale projects include the Gondwana Link which is a collaborative effort entering its thirteenth year of achievement, an inspiring example of how a broad spectrum of local, regional and national groups can work together. With the support of Gondwana Link Ltd, these groups are:

- restoring ecological connectivity across south-western Australia, from the dry woodlands of the interior to the tall wet forests of the far south-west corner;
- protecting and restoring biodiverse bushland on an unprecedented scale; and
- building a living link that reaches eastward across the continent (Gondwana Link, 2016).

4.10 As individuals and communities:

Actions which individuals can take to conserve habitats and reduce their impact on the environment include: conserve habitats in reserves (become involved in a local Landcare group), conserve habitats on farms, control exotic plants and animals, recycle, create less rubbish, use less water, don't destroy the bush, establish native gardens, learn more and teach others.

With help from everyone, Australia's threatened species have a greater chance of survival.

5. RECOMMENDED ACTIVITIES

5.1 ACTIVITY ONE: Talking with the Experts: Threatened Esperance Species
In field (desirable) or class presentation. Allow 1-2 hours.

Overview:

Students will meet with an expert working (or volunteering) in the field of threatened species. Students will then be asked to summarise the key points presented by the speaker. These reports could be utilised as part of the research for Activity Two.

Required Resources:

- One copy for each student of Talking with the Experts: Student Report Worksheet (Appendix 1).
- Pens, pencils.
- Resources as required by visitor.

Teacher Preparation:

- Read Teacher Background Information in Threatened Species lesson plan.
- Arrange for a visitor to either meet in the field or in the class room. The visitor could suggest a suitable location with an excursion into the field being highly desirable. Suggested speakers who could be approached include:
  - Department of Parks and Wildlife, Esperance District, Nature Conservation Officer:
    92 Dempster Street ESPERANCE
    PO Box 234 ESPERANCE 6450
    Phone (08) 9083 2100 Fax (08) 9071 3657,
  -South Coast Natural Resource Management, Esperance Office, Biodiversity Implementation Officer:
    Unit 4, Suite B, 113 Dempster Street ESPERANCE, WA 6450
    PO Box 1801 ESPERANCE, WA 6450
    Phone: (08) 9076 2209
  -Shire of Esperance, Environmental Officer:
    Windich Street ESPERANCE
    PO Box 507 ESPERANCE WA 6450
    Phone: (08) 9071 0666
  -Esperance Bird Observers Group
  -Esperance Wildflower Society
- Provide a copy of Talking with the Experts: Student Report Worksheet to the visitor to ensure they can appropriately plan their presentation. The visitor may suggest other topics and may decide to present on a broad range of issues or focus on one particular species. This is more than suitable and the worksheet will cater for both approaches.

Procedures:

1. Define threatened species and talk through with the students that when biodiversity is impacted upon (threats to Biodiversity as presented in Teacher Background Information for Biodiversity lesson plan), it can lead to species and ecosystems wellbeing and survival being threatened.
2. Define endemic species.
3. Meet with and host "Talking with the Experts: Threatened Esperance Species" session.
4. Have the students complete the Talking with the experts: Student Report Worksheet.
5. Share and discuss.

5.2 ACTIVITY TWO: South Coast Fauna Under Threat
Classroom activity. Allow 1.5 – 2 hours.

Overview:

Students will use their power of investigation and thinking skills to study a threatened or critically endangered endemic species in the Esperance region. They will gain an understanding of the species and why it is threatened and then identify some actions that are being taken to assist the species and its ecosystem. The students will also consider some actions they may take as individuals or as a school community.

Required resources:

- Computers/ tablets with internet access (potentially with printing access or data storage and retrieval).
- Library resources.
- Note pad and pens/ pencils.

Teacher Preparation:

- Read Teacher Background Information in Biodiversity lesson plan.
- Become familiar with the Western Ground Parrot.

Procedures:

1. Discuss the concept that when biodiversity is impacted on, it can result in changes to species and ecosystems. Brainstorm with the students what actions and activities could impact on biodiversity and make a list for the class to see.
2. Define what threatened species means. Define what an endemic species is.
3. Introduce some of Esperance's threatened plant and animal species. These include: the Carnaby's Black Cockatoo (classified as Endangered), the Hooded Plover (classified as Critically Endangered), the Western Ground Parrot (classified as Critically Endangered) and the Chuditch (classified as Vulnerable). A key threatened plant species in the Esperance region is *Lambertia echinata subsp: echinata*, the Prickly Honeysuckle (classified as Endangered). Esperance is also home to the threatened ecological community of 'Proteaceae Dominated Kwongkan Shrublands'.
4. Divide students into two groups. Allocate each group a threatened species from the Esperance area (as above) to research and present on. Each group is then to be split up into 4 sub-groups and each sub-group will then research one of the following topics about their groups allocated threatened species (encourage students to use dot points and gather 3-4 images to assist them in sharing what they have found out):
   - **Identification and behaviour**: what does the animal or plant look like and how does it behave (ie: for animal what is its diet, is it nocturnal, what is its life expectancy),
   - **Distribution and habitat**: where can the plant or animal be found (geographically and what type of habitats),
   - **Threats**: what threats is that plant or animal under and susceptible to that has led them to be classified as threatened? What conservation classification does it have?
   - **Actions**: What action is being taken to assist the species? What could we do as individuals to assist in the conservation of the species?
5. Bring the students together and have each group present their findings to the class (each sub-group should speak to the topic that they researched).
6. Lead a class discussion on what the individual students and school community can do to assist in threatened species conservation. These actions can be to assist the species directly ie: propagate local native plants, remove weeds and enhance habitats, build nest boxes for threatened bird species (Carnaby's Cockatoo), or could be general sustainability and environmental protection focused activities ie: engage in a reduce-reuse-recycle program, start up a rubbish-free lunch policy.
7. Reflect on all key terms: biodiversity, species and ecosystem and how they are all interconnected. Reflect on how humans are a part of nature and that they do impact on biodiversity. Encourage students to be aware that there are many people and groups working with scientists and government to learn more about biodiversity and how to protect and assist it.

SUGGESTED FURTHER READING:

Birdlife Australia: http://birdlife.org.au

South Coast Natural Resource Management: http://southcoastnrm.com.au/

Gondwana Link: http://www.gondwanalink.org/

Department of Environment: https://www.environment.gov.au/topics/threatened-species-ecological-communities

Department of Parks and Wildlife: https://www.dpaw.wa.gov.au/plants-and-animals

DIGITAL MEDIA:

Title and Description	At:
"Steps to Recovery: Carnaby's Black Cockatoo Recovery Project": DVD.	Contact Birdlife Australia for a copy.
"Remote and Rugged – Western Ground Parrot" A Vimeo video excerpt of the SCNRM Remote and Rugged DVD which talks about the threats to native fauna from cats and foxes and then presenting more details on the Western Ground Parrot	https://vimeo.com/84140945

VOCABULARY:

Endemic: native to a certain area and found nowhere else

Feral: wild not domesticated or cultivated

Native: belonging to a particular place through birth or germination.

Threatened: a species or community that is vulnerable, endangered or presumed extinct (as defined in the *Environment Protection and Biodiversity Conservation Act 1999*

REFERENCES:

Department of Environment (2016a) *Threatened species under the EPBC Act*, at: https://www.environment.gov.au/biodiversity/threatened/species

Department of Environment (2016b) *About threatened ecological communities*, at: https://www.environment.gov.au/biodiversity/threatened/communities/about#tec

Department of Parks and Wildlife (DPaW) (2016) Threatened species and communities, at: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities

Gondwana Link (2016) Welcome to Gondwana Link, at: http://www.gondwanalink.org/

International Union for Conservation of Nature (IUCN) (2016) *IUCN Red List of Threatened Species*, at: http://www.iucn.org/resources/conservation-tools/iucn-red-list-threatened-species

South Coast Natural Resource Management (SCNRM) (2016) *Biodiversity*, at: http://southcoastnrm.com.au/our-themes/biodiversity

The Nature Conservancy (2016) *Wildlife and Habitat*, at: http://www.natureaustralia.org.au/our-impact/wildlife/?src=-sea.AWG&gclid=Cj0KEQjw7LS6BRD02Iz23au25OQBEiQAQa6hwGeRNheABd09g-HZLJv7f53bIxY4we3AGadVC8dmBb0aAp-d_8P8HAQ

THREATENED SPECIES
Appendix 1: Talking with the experts: Student Report Worksheet

Name: _____

Visitors Name: _____

Where do they work or volunteer:

_____

_____

_____

_____

_____

What do they do to help threatened species?

_____

_____

_____

_____

_____

What is a threatened species? Give example/s of Esperance threatened species.

_____

_____

_____

_____

_____

What is a habitat?

_____

_____

_____

_____

_____

What do native animals need to survive?

_____

_____

_____

_____

_____

How do human's impact on plant and animal species?

_____

_____

_____

_____

_____

How can we work together to conserve plants and animals?

_____

_____

_____

_____

_____

NATIVE VEGETATION AND WEEDS

1. OVERVIEW

Students will gain an understanding about the difference between native vegetation and weeds and how weeds, as a threatening process, can negatively impact on biodiversity. The students will also learn about basic plant parts and gain a more detailed understanding of Bridal Creeper, which is an environmental Weed of National Significance growing in the Esperance region.

2. LINKS TO AUSTRALIAN CURRICULUM

STRAND	SUB-STRAND / KEY ORGANISING IDEAS
MATHEMATICS Statistics and probability	Data representation and interpretation
SCIENCE Science as a human endeavour	Nature and development of science Use and influence of science
Science inquiry skills	Communicating Evaluating Planning and conducting Processing and analysing data and information
Science understanding	Biological sciences

3. OBJECTIVES

Students will:

- Understand that weeds in a natural environment have a negative impact on biodiversity.
- Begin to develop skills to differentiate between a weed and a native plant and identify basic plant parts.
- Gain a detailed understanding of Bridal Creeper (how it was introduced into Australia, why the plant is such a bad weed and the different methods used to control it).

TOPICS
Native vegetation
Weeds
Plant identification

PHASES OF LEARNING
3-6, 7-9

SITE (LOCATION)
Classroom
School grounds

ACTIVITIES
1 In class/outdoors (1 – 2 hrs)
2 In class (1 hr)

MATERIALS

- Outdoor area with a range of native vegetation and weeds (could be the school ground and gardens or a site visit),
- Coloured pencils,
- Lead pencil and eraser,
- iPad or other image capturing device
- Clipboards,
- A hand lens or magnifying glass
- Plant Parts and Form Work sheet
- Copies of "Weed Management Guide: Bridal Creeper"
- Smart board or other multi media with internet access for viewing You Tube video.
- Bridal Creeper Worksheet (Appendix 2).
- Pencils/ pens.

STUDENT WORKSHEET
Plant Parts and Form
Bridal Creeper Worksheet

4. TEACHER BACKGROUND INFORMATION

4.1 What is native vegetation and what are weeds?

Western Australia's Environmental Protection Authority defines native vegetation as "any local indigenous plant community containing, throughout its growth, the complement of native species and habitats normally associated with that vegetation type or having the potential to develop these characteristics. It includes vegetation with these characteristics that has been regenerated with human assistance following disturbance. It excludes plantations and vegetation that has been established for commercial purposes" (EPA, 2000). So essentially, native vegetation is comprised of native plants growing in their natural habitat.

Australia's native vegetation is one of the richest and most fundamental elements of our natural heritage. On a world stage, Australia is a stand out with a staggering 24,000 species of native plants having been identified, compared to England's 1,700 native plants (Australian Government, 2016). The vegetation of Australia contributes significantly to the uniqueness and importance of Australia's biodiversity. Native vegetation is a critical element of biodiversity.

A weed is a plant that is out of place or growing where it does not belong or where it is not wanted. A weed requires some form of action to reduce its effect on the environment, the economy, human health and amenity. Weeds are also known as invasive plants. A weed can be an exotic species (many of the weeds in Australia have come from Europe and Africa) or a native plant species that colonises and persists in an ecosystem in which it did not previously exist. Nationally the impact of weeds continues to increase with exotic species accounting for about 15% of all flora here in Australia. This figure is increasing by about 10 species per year (Department of Environment, 2016b).

Weeds typically produce large numbers of seeds, assisting in their spread. Weed seeds are spread by wind, waterways, people, vehicles, machinery, birds and other animals (such as introduced animals such as rabbits, cattle, goats and pigs). Many weeds have protective features such as thorns, spines and poisons which animals sometimes know to avoid which limits the pressure on the weed plants survive. Most weeds are also free of natural predators or parasites in the new areas they invade thus allowing them to grow and reproduce more vigorously than they would in their own natural environment (Gould League, 2002). Weeds thrive in agricultural and urban areas where fertilizers and other wastes are washed into bushland, leaving extra nutrients in the soil to feed the weeds. All of these factors give rise to a weeds ability to thrive, survive and rapidly reproduce in a range of environments, particularly degraded and disturbed environments where they are commonly the first species to colonise and dominate in these conditions (Australian Government, 2016).

Key types of weeds are:
Environmental weeds: plants that invade natural ecosystems and adversely affect the survival of native vegetation (flora) and fauna.
Weeds of National Significance: are environmental weeds which have been identified and agreed upon by all of the Australian governments based on their potential for spread and environmental, social and economic impacts (Department of Environment, 2016c). There are currently thirty two environmental weeds on the Weeds of National Significance list.
Agricultural weeds: plants which grow and negatively impact on agricultural production.

4.2 Why is native vegetation so important?

Recall that in the Esperance Environmental Educational Program, Biodiversity lesson plan, the significance of the biodiversity of the South West Botanical Province, the South Coast and Esperance region was outlined. Native vegetation is a key component of a healthy environment and assists in maintaining biodiversity in that it:

- binds and nourishes our ancient Australian soils,

- controls erosion through protecting soils and riverbanks,
- reduces land degradation and salinity,
- improves water quality and availability,
- shelters and sustains wildlife by providing habitat for a wealth of unique biodiversity (including threatened species),
- provides natural resources to support economic development, and
- stores a significant amount of carbon, mitigating the effects of climate change, and emits oxygen.

The depletion and destruction of native vegetation is the primary driver of land degradation, salinity and declining water quality, and is one of the biggest causes of biodiversity loss. While broad scale land clearing of native vegetation for agriculture and urban development is a critical threat, the loss caused by clearing is compounded by the degradation of remnant vegetation through unsustainable grazing pressure, insect attack, disease, weeds, rising water tables, salinity, inappropriate fire management, unsustainable firewood gathering and neglect.

There is a growing body of evidence related to the benefits of native vegetation to both on-farm production and broader catchment values.

4.3 Why are weeds such an issue?

4.3.1 Impacts on the environment

Weeds are among the most serious threats to Australia's biodiversity because they:

- outcompete native vegetation for light, nutrients, water and space,
- become the dominant vegetation system in an area (particularly degraded and/ or highly disturbed environments),
- lead to reduction in native vegetation diversity,
- change the native vegetation community and ecology which is supporting and providing habitat to native animals,
- can harbour pests and diseases, and
- can create areas of increased flammability, altering natural fire regimes.

4.3.2.Impact of weeds on the economy

Australia spends considerable time and money each year in combating weed problems and protecting ecosystems and primary production on private and public land (Department of Environment, 2016b). Weeds reduce the quantity and quality of Australia's agricultural, horticultural and forestry products, affecting both industry and consumers. Weeds invade crops, smother pastures and some can harm livestock with some weeds being toxic to stock (Natural Resource Management Ministerial Council, 2007).

In 2007 it was estimated that weeds cost Australian farmers around $1.5 billion a year in weed control activities and a further $2.5 billion a year in lost agricultural production, that's a combined economic impact of $4 billion per annum (Natural Resource Management Ministerial Council, 2007). Agricultural land and water managers incur material and labour costs to control weeds and these costs are then passed on to the Australian public through higher prices for produce (Department of Environment, 2016b).

With regard to the costs of environmental weeds in natural environments and recreational areas, the cost is difficult to calculate, however it is expected that the cost would be similar to, if not greater than, that estimated for agricultural industries (Department of Environment, 2016b). There are also indirect costs where weed control is required for human health and amenity reasons.

4.3.3 Impacts on human health and amenity

Weeds can cause human health problems such as allergies, skin irritation, asthma and other respiratory problems (especially in children) and poisoning. Some water weeds can affect the quality of our drinking water and the quality of water in waterways if infestations are not managed (Department of Environment, 2016b). Weeds can impact on recreational pursuits (leading to impacts on the tourism industry), safety in the natural environment and the aesthetics of the Australian natural environment. The presence of weeds can also increase the fire load and alter fire regimes which is a further threatening process (with invasive plants being a threatening process itself) leading to the decreased resilience and greater pressures on biodiversity.

4.4 Native vegetation and weeds in Australia and the Esperance Region

The South Coast region is home to more than 5,472 known flora taxa (species and sub-species) many of which are endemic. This great floral diversity has been grouped into 120 native vegetation associations (a vegetation association is a grouping of flora species), again many of which are endemic (SCNRM, 2011).

Parts of the South Coast region's native vegetation have been protected within the conservation reserve systems (in the Esperance region this includes Jerdacuttup Lakes and Lake Shaster nature reserves and the Stokes, Cape Le Grande and Cape Arid national parks), particularly around waterways and broader landscape geographic areas (ie: Stirling Ranges). However, several vegetation associations have less than 15% of their total remaining extent protected in the reserve system and some associations are not found in these areas at all (SCNRM, 2011). Further to the reserve systems, there is a mosaic of protected native vegetation on farms across the region. Recall from the Esperance Environmental Education Program Threatened Species lesson plan that Esperance is home to a number of threatened species and a threatened ecological community.

Significant weed problems exist at the national, state, territory, regional and individual landowners' level. Weeds have the potential to, and indeed are, impacting on globally significant areas such as the South West Botanical Province of WA which is an identified 'biodiversity hotspot' (one of 34 in the world), RAMSAR-listed wetlands (in the Esperance area there is Lake Gore and Lake Warden) and cultural heritage sites. Weeds impact on the habitats of threatened species and the national and state nature reserves, national parks and other high value areas of native vegetation.

Weeds which occur on the South Coast which are listed as Weeds of National Significance and declared under the Agriculture and Related Resources Act (1976) are gorse, blackberry, bridal creeper, skeleton weed and three-cornered bed straw. Other environmental weeds threatening biodiversity include the Victorian tea-tree, Sydney golden wattle and other introduced Acacia species, African boxthorn, golden dodder and lantana which are often well-established along roadsides and in bushland (SCNRM, 2011). Many of these weeds are present in the Esperance region.

4.5 What is being done about weeds?

Weeds are a problem for everybody and require a long-term coordinated approach for successful control and eradication. There are a range of stakeholders including: federal, state and local governments, natural resource management groups, gardeners, farmers, hobby farmers, community organisations (such as catchment groups or Landcare groups), the nursery, garden and landscaping industries, the transport industry, children and youth. Each of these stakeholders plays a role in identification, monitoring, controlling and eradicating weed.

The overarching policy for weed management in Australia is the Australian Weeds Strategy, which outlines goals and actions required to keep Australia's economic, environmental and social assets secure from the impacts of weeds. (Department of Environment, 2016d). The Australian Weeds Strategy provides a national framework to guide and complement state, territory, regional and local government strategies and industry initiatives that are ultimately translated into strategic on-the-ground actions to manage weed problems and protect assets. This strategy complements national and state legislative controls, including the implementation of Australia's international obligations to protect biodiversity and plant health status (Natural Resource

Management Ministerial Council, 2007).

To protect Western Australian agriculture the Department of Agriculture and Food, Western Australia regulates harmful plants under the *Biosecurity and Agriculture Management Act 2007*. Plants that are prevented entry into the State or have control or keeping requirements within the State are known as declared pests (DAFWA, 2016).

A range of activities across Australia are being carried out by a range of stakeholders to prevent, control and mitigate the impacts of weeds in Australia. Weed control activities include:

- Education and awareness raising about weeds and their control.
- Preventing the entry of new weeds into Australia which is governed by Australian Government law.
- Monitoring and evaluation to allow for early detection and to then determine the extent and possible range of the weeds spread, the weeds response to weed control measures and then also the health of the native vegetation. Monitoring and evaluation is an essential component of managing weeds.
- Prioritisation of weeds. Prioritisation allows for finite resources (such as labour and funding) to be best invested.
- Weed containment, control and eradication measures which include: biological control (releasing a weeds natural enemy to such as insects, diseases and grazing pressures), cultural control (manipulating farming practices or enhancing the native vegetation in an area), physical control (removal of the weeds by mowing, mulching, tilling, burning, grazing or by hand), chemical control (use of chemicals such as herbicides). Often weed control is carried out prior to seed set to reduce the amount of viable seed being produced. Integrated weed management programs are a long-term approach which use a range of containment, control and eradication measures.
- Ongoing maintenance of areas of weed eradication are essential and require long-term commitments and again, monitoring and evaluation is critical. Ongoing maintenance is site specific but can involve soil stabilisation measures, revegetation with native vegetation species and follow up control measures. Failing to carry out ongoing maintenance can result in reinfestations of the original target weed and potentially other weeds.

SUGGESTED ACTIVITIES

5.1 ACTIVITY ONE: Native Vegetation and Weeds in Esperance
In-class, on-school grounds or in field. Allow 1-2 hours.

Overview:

This activity (adapted from Weedsbusters, Gould League, 2002) will introduce the students to the various parts of plants and the forms in which they grow. The activity will introduce the students to native vegetation and weeds and will allow them to become familiar with some of the more commonly found natives and weeds.

Required Resources:

- Outdoor area with a range of native vegetation and weeds (could be the school ground and gardens or a site visit),
- Coloured pencils,
- Lead pencil and eraser,
- iPad or other image capturing device
- Clipboards,
- A hand lens or magnifying glass and
- Plant Parts and Form Worksheet (Appendix 1).

Teacher Preparation:

- Read Teacher Background Information in Vegetation and Weeds lesson plan.
- Become familiar with some of Esperance's worst weeds and the difference between native vegetation and weeds.
- Make one copy for each student of the Plant Parts and Form Worksheet (Appendix 1).
- Potentially organise for a plant specialist to attend the school or field site to assist the children in distinguishing between a weed and native plant (contact South Coast Natural Resource Management or a local nursery for a suggested person if you require assistance in this area).
- Become familiar with the Weeds Australia website which has a Weed Identification and Information tool (direct link: http://www.weeds.org.au/weedident.htm).

Procedures:

1. Inform students that there are a variety of plants in the world. There are grasses, trees, shrubs, climbers, water plants, bulbs etc. Outline the main parts of a flowering plant. This could be simply drawn on a board for the students or the website credited could be displayed (as shown in Figure 1).

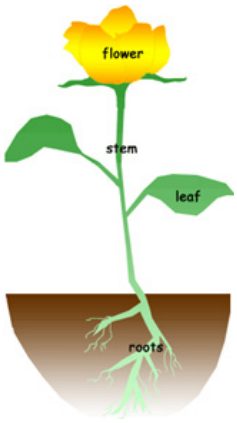

Figure 1: Basic plant parts.
(Source: Missouri Botanical Garden at: http://www.mbgnet.net/bioplants/parts.html)

2. Define native vegetation and weeds to the students. Emphasise that native vegetation supports the biodiversity of Esperance and that our healthy environments can be negatively impacted by the invasion of weeds (plants that don't belong in a certain environment). Inform the students that Esperance has a great diversity of native plants but it also has a great number of weeds. Some of these weeds are very significant and are on the Weeds of National Significance list (this provides a lead in to Activity Two).
3. Take students out into the school yards and gardens, or potentially into the field (see notes in Introduction document with regard to potential field visit sites).
4. Instruct students to look at the vegetation present. Students should then select either a native or weed species to focus their study on (ensure there is a mix across the class, students could work in pairs and have a weed and native between them).
5. Have the students examine their selected plants carefully and then draw them. The students could also capture an image of their chosen plants.
6. Have the students label their plant parts on their drawings: stems, leaves, flowers, seeds, fruits, thorns, tubers, tendrils and roots.
7. Have students complete the Plant Parts and Form Worksheet.
8. Lead discussion on the variety of plants studied. Emphasise that the presence of weeds is a threat to health of that environment. Questions to provoke discussion could include: Where there any special parts on the plants that made them a better weed or a more successful/ resilient native? Is this a weedy environment? What could be done in this environment to improve the natural habitat? How many weeds were there?

How many natives? What percentage of the plans identified were weeds versus native? Where there more types of certain plants in that area?

5.2 ACTIVITY TWO: A Weed of National Significane in the Esperance Region - Bridal Creeper.
In-class research and comprehension actvity. Allow 1 hour.

Overview:

Bridal creeper is an environmental weed and is listed as a Weed of National Significance. It is found across a large area of Australia and is present in Esperance. This activity will allow the students to focus their attention and learn more about one of the regions worst weeds.

Required Resources:

- Copies of "Weed Management Guide: Bridal Creeper" (Appendix 3) or enable access to the internet for the students to read the document online at: http://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/wons/pubs/a-asparagoides.pdf
- Smart board or other multimedia with internet access for viewing You Tube video.
- Bridal Creeper Worksheet (Appendix 2).
- Pencils/ pens.

Teacher Preparation:

- Read Teacher Background Information in Vegetation and Weeds lesson plan.
- Become familiar with Bridal Creeper by reading "Weed Management Guide: Bridal Creeper".
- Make copies of "Weed Management Guide: Bridal Creeper" or provide students with the link.
- Secure internet and class viewing for the You Tube video "Weed Info: How to Control Bridal Creeper" at: https://www.youtube.com/watch?v=Bg1Dx23NdQI.
- Make one copy for each student of the Bridal Creeper Worksheet (Appendix 2).

Procedures:

1. Provide students with a brief introduction of Bridal Creeper.
2. Provide students with the Bridal Creeper Worksheet.
3. Show students the "Weed Info: How to Control Bridal Creeper video".
4. Provide students with the "Weed Management Guide: Bridal Creeper" (either hand out or online) to assist them in completing the worksheet.
5. Go through answers to the worksheet as a class and discuss the presence of the weed locally. Has anyone seen it?

FOR FURTHER READING:

Weeds Australia; An Australian Weeds Committee National Initiative. http://www.weeds.org.au/

The Weeds Society of WA Inc.: http://www.wswa.org.au/

Department of Environment; Weeds in Australia:
http://www.environment.gov.au/biodiversity/invasive/weeds/index.html

DIGITAL MEDIA:

Title and Description	At
"Weeding Out" ABC Landline A 10.50min online video about one of Australia's most underestimated environmental threats: weeds. Focus on the Rubber Vine (a Weed of National Significance) in Kimberley.	http://www.abc.net.au/landline/content/2015/s4267598.htm?site=westqld
"Weed Info: How to control Bridal Creeper" Adelaide and Mount Lofty Ranges Natural Resources Management Board. A 14.53min YouTube video covering identification, biology, issues and control options for Bridal Creeper. It also includes a case study looking at the work of the Friends of Newland Head have been doing to control Bridal Creeper.	https://www.youtube.com/watch?v=Bg1Dx23NdQI

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http://www.weeds.org.au/docs/weedbst.pdf

Natural Resource Management Ministerial Council (2007) *The Australian Weeds Strategy*. Retrieved on 13th May 2016 from: http://www.environment.gov.au/biodiversity/invasive/weeds/publications/strategies/weed-strategy.html

South Coast Natural Resource Management (2011) *Southern Prospects 2011-2016*, Albany, Western Australia.

Appendix 1: Plant Parts and Form Worksheet (page 1 of 2)

Draw your plant and label its main parts.

Appendix 2: Plant Parts and Form Worksheet (page 2 of 2)

Can you name your plant? _____

Where is your plant growing? _____

Is your plant a native plant or a weed? _____

Is your plant a (tick one):

- ☐ Tree
- ☐ Shrub
- ☐ Grass
- ☐ Climber/ vine
- ☐ Water weed
- ☐ Bulb/ corm/ tuber

	Present (Yes or No)	Shape	Size	Colour	Smell	Texture
Leaves						
Stem						
Tendrils						
Roots						
Tuber						
Seed						
Flowers						
Fruits						

Has anything been eating your plant? _____

Does your plant smell? Does the smell remind you of anything? _____

What animals might eat your plant (Note: Don't try them yourself – they may be poisonous)?

_____

If your plant is a weed, which parts of the plant help it grow as a weed (for example: thick stems, prickly leaves)?

_____

If your plant is a native, what features assist in creating a good habitat for animals and other plants (for example: shady leaves, branching stems)?

_____

Bridal Creeper Worksheet

1. Describe what Bridal Creeper looks like (colour of leaves, form of growth, colour of fruit etc.):

2. Where did Bridal Creeper come from and how did it come to be in Australia? When did this occur?

3. Where does Bridal Creeper like to grow in Australia?

4. How does Bridal Creeper spread?

5. Why is Bridal Creeper such a bad weed? How does it impact on the native vegetation?

6. What are some of the ways that Bridal Creeper can be controlled?

_____

_____

_____

_____

_____

7. What things can we do as individuals to stop the spread of Bridal Creeper?

_____

_____

_____

_____

_____

PHYTOPHTHORA DIEBACK

1. OVERVIEW

Students will understand the effects of Phytophthora Dieback on native vegetation.

2. LINKS TO AUSTRALIAN CURRICULUM

STRAND	SUB-STRAND / KEY ORGANISING IDEAS
SCIENCE Science as a human endeavour	Nature and development of science Use and influence of science
Science inquiry skills	Communicating Planning and conducting Processing and analysing data and information
Science understanding	Biological sciences

3. OBJECTIVES

Students will:

- Understand how dieback is spread.
- Become aware of what they can do to stop the spread of dieback.
- Learn how to raise awareness of dieback to people and the community around them.

4. TEACHER BACKGROUND INFORMATION

4.1 What is phytophthora dieback?

Phytophthora dieback is caused by an introduced plant pathogen, Phytophthora cinnamomi, which lives in soil and attacks the roots of native plants. Dieback is a symptom of a Phytophthora infection whereby plants die because they cannot

TOPICS
Phytophthora dieback
Plant pathogen
Impacts of dieback on biodiversity

PHASES OF LEARNING
3-6, 7-9

SITE (LOCATION)
Classroom

ACTIVITIES
1.1 In class (1 – 2 hrs)
1.2 In class (1 – 2 hrs)
2 In class (1.5 hrs)

MATERIALS
- A4 paper
- Pencils, textas, crayons
- A0 paper for recording information
- Copies of bushland poems for each student
- Plastic straws.
- Pins.
- Cups and water.
- Timers.
- Smartboard or other multimedia and internet access for viewing of "Stop the Rot".
- A0 Paper for recording information.
- One sheet of A0 paper per group of 3 - 4 students.
- Crayons/ textas/ coloured pencils.

take up the water and nutrients they need to survive (Department of Parks and Wildlife, 2016). There are over 140 species of Phytophthora, but the species that causes the most severe and widespread damage to native plants in Western Australia is Phytophthora cinnamomi (Dieback Working Group, 2016). Plant species affected by Phytophthora dieback suffer rotting of their root system so they appear to be dying of drought (Department of Parks and Wildlife, 2016). Dieback spores can remain in the soil for a long time and become active in warm and moist favourable conditions. Unfortunately there is no simple way of knowing if dieback is in an area (Dieback Working Group, 2016). Figure one outlines the life cycle of dieback.

When a dieback spore infects a plant's root, the mycelium grows through the root hairs and into the roots clogging up the water transport cells and eventually rotting the plant tissue. The plant can still absorb water through other roots and remain alive as the dieback grows throughout the roots but eventually the plant can no longer obtain enough water and it will die rapidly – as quickly as few days in hot weather – even for large trees. Trees and plants will show little or no sign of stress in the early stages or in wet weather but during warmer weather the dieback mycelium grows more rapidly, there may be multiple infections and the strain of the plant needing more water is just too much!

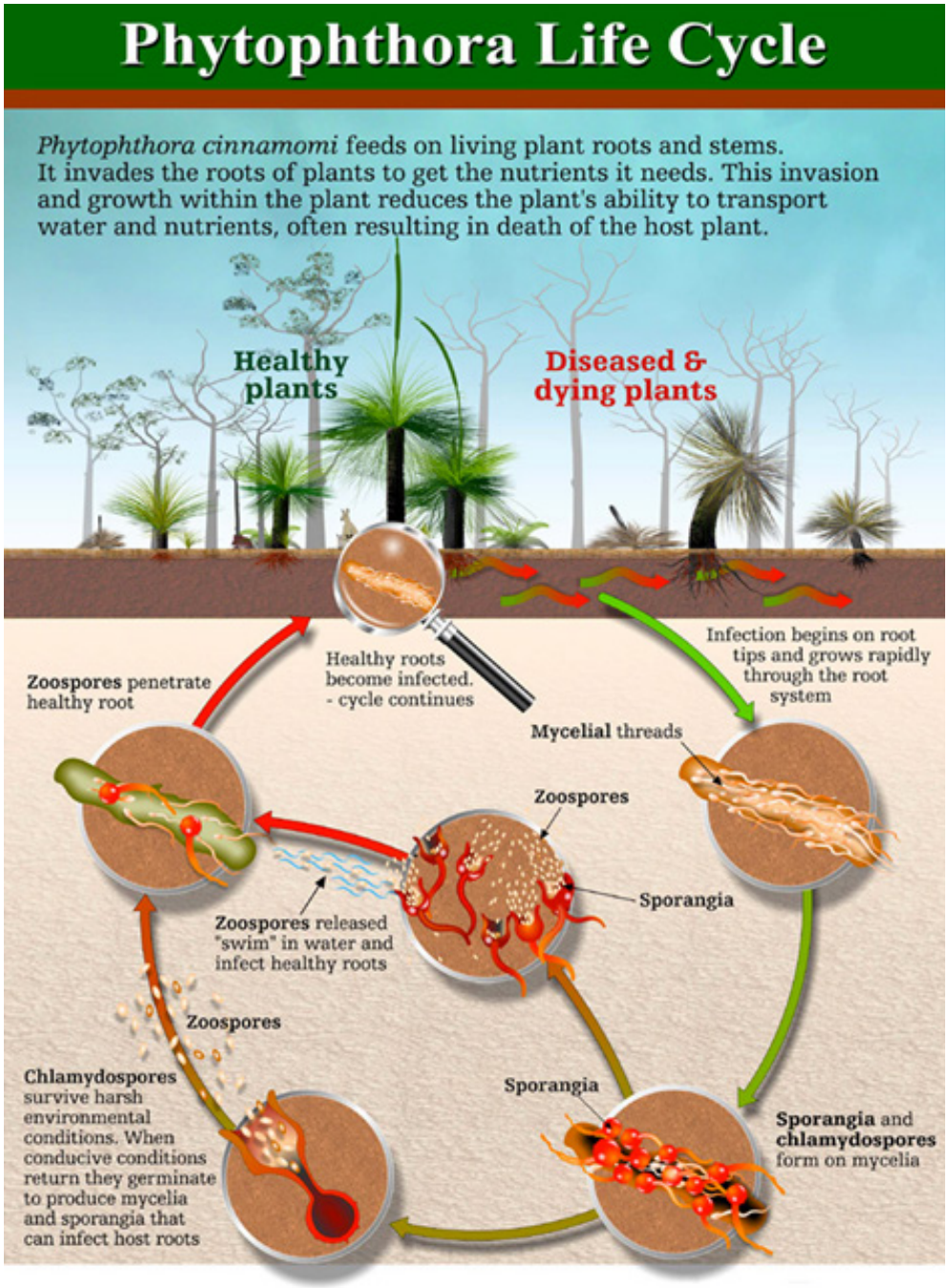

Figure 1: Life cycle of Phytophthora cinnamomi (Dieback Working Group, 2016)

4.2 Priority bushland in Australia and the Esperance Region

Over 40 % of native Western Australian plants and over 50 % of rare and endangered flora are susceptible to Phytophthora dieback (Dieback Working Group, 2016). The invasive pathogen is a significant issue across the South Coast Region of Australia as it threatens regionally and nationally significant areas of biodiversity. Figure two shows the presence of dieback in the South West of Western Australia which is identified as a global biodiversity hotspot.

The South Coast Region encompasses the southern and eastern parts of the Southwest Botanical Province where the diversity of landform and soil types and long history of isolation have produced a very diverse flora (South Coast NRM, 2016). The reserves across the South Coast Region contain a high proportion of the remaining vegetation, priority bushland reserves across the Esperance Region include Beringa Reserve, Coramup Creek Reserves, Lake Monjingup, Munglinup Beach Reserve and Chertninup Creek Reserve (Bush Heritage, 2016) (Shire of Esperance, 2016). Some natural areas are well connected across the landscape, while others act as stepping stones with limited or no connectivity (South Coast NRM, 2011). As conservation efforts continue, it is vital that these areas are protected from weed invasion and Phytophthera dieback.

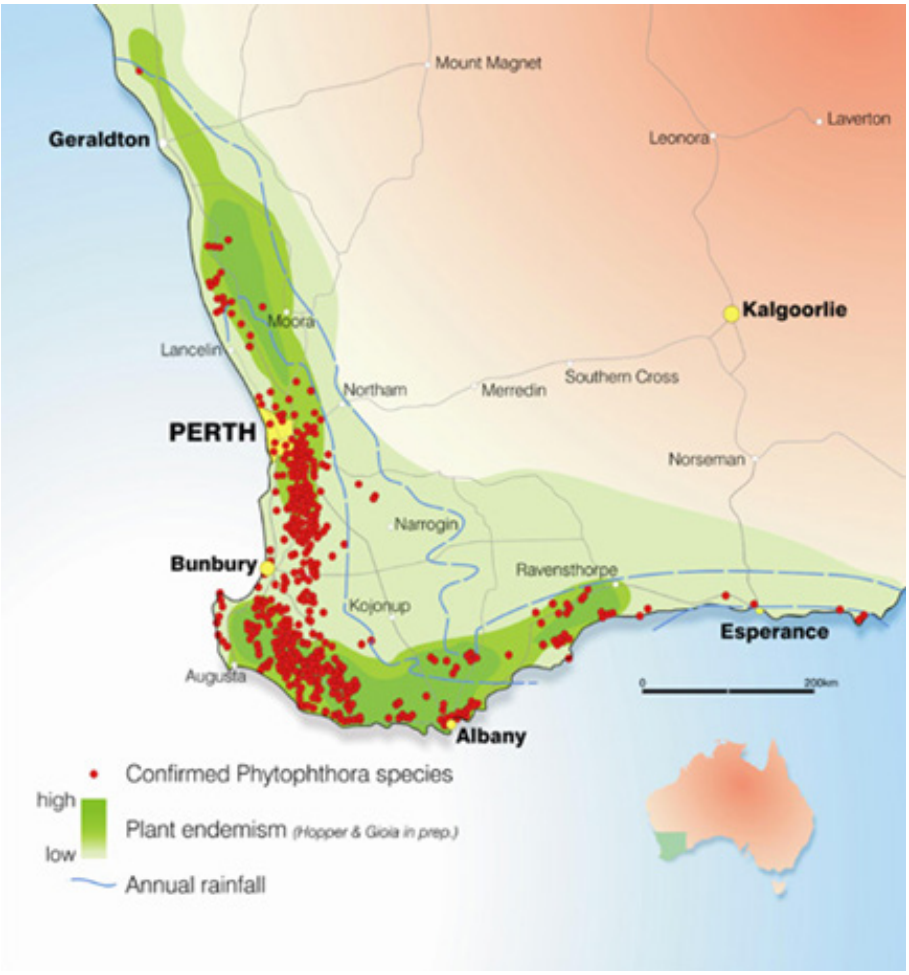

Figure 2: Distribution of Phytophthora dieback (Department of Parks and Wildlife, 2016)

Aside from widespread pockets of bushland across the Esperance Region, the area also contains three national parks: Cape Le Grand, Stokes and Cape Arid. These parks form the cornerstone of biodiversity conservation in Esperance, containing vital habitat that provides safe havens in which animals and plants can survive and thrive. Together with other protected areas, they provide a 'backbone' of core conservation areas that can be linked by conservation efforts across different tenures, supporting a diverse, healthy and resilient environment (Office of Environment & Heritage, 2016). The National Parks of Esperance provide habitat to a stunning array of native flora and fauna, many species of which are threatened or endangered.

4.3 Threats to biodiversity from Phytophthora dieback in the Esperance Region

Phytophthora spores are spread in soil and water. Natural spread is about one metre per year uphill but spread downhill can be far greater because spores can move in water running through the soil or in water moving along the cap-rock under the soil (Alcoa, 2016). However, it is human activity that causes the most significant, rapid and widespread distribution of the pathogen. Road construction, earth moving, driving infested vehicles on bush roads and stock movement can all contribute significantly to the spread of Phytophthora dieback (Dieback Working Group, 2016).

When Phytophthora dieback spreads to bushland, it kills many susceptible plants, resulting in a permanent decline in the diversity of the bushland. It can also change the composition of the bushland by increasing the number of grasses and reducing the number of shrubs (Dieback Working Group, 2016). Native animals that rely on susceptible plants for survival are reduced in numbers or are eliminated from sites infested by Phytophthora dieback (Department of Parks and Wildlife, 2016).

National parks and regionally significant bushland reserves across Esperance are all at risk to infection from Phytophthora dieback. There are several pockets across the region that are already affected and management of the spread of this deadly pathogen is paramount.

4.4 What can be done to address the spread of Phytophthora dieback in the Esperance Region

Successfully reducing the spread of Phytophthora dieback requires ongoing community involvement. It's an important issue for home gardeners, landscapers, new home builders, off-road vehicle enthusiasts and bushwalkers. Communities need to ask for 'dieback – free' materials such as soil, gravel, potting mix, mulch and plants, prevent the spread of soil or mud around bushland, and observe signage in their local bushland reserve. Before entering and exiting bushland people need to ensure all clothing, hats, footwear, tools, equipment, machinery and vehicles are free of mud, soil and organic matter (Department of Environment, 2016).

5. SUGGESTED ACTIVITIES

5.1 ACTIVITY ONE: Understanding Phytophthora dieback

Overview:

This activity has two parts. In this activity, students will develop an appreciation for the different values of bushland and how Phytophthora dieback threatens these important areas of native biodiversity. Part two has the students seeing the effect of the rotting of plant root tissue on the ability of a plant to suck up water, simulating the unhealthy root by piercing a straw with a pin above the water line.

PART ONE: Why is bushland important?
In class activity. Allow 1 to 2 hours.

Required Resources:

- A4 paper
- Pencils, textas, crayons
- A0 paper for recording information
- Copies of bushland poems for each student

Teacher Preparation:

- Read Teacher Background Information in Phytophthora Dieback lesson plan.

- Familiarise yourself with priority bushland areas in the Esperance Region, background information is provided in Section 4 of this lesson plan and in Section 4 of the Biodiversity education program.
- Read through the selection of Australian bushland poems provided in Appendix 1. These poems cel ebrate the uniqueness of bushland areas and the different animals that rely on bushland habitat. The poems are divided into lower and upper primary school levels.

Procedure:

1. Share with your class a selection of bushland poems.
2. Ask students to close their eyes and visualise an area of bushland that they have been to. Ask them to visualise the different plants and animals that they would see in that environment. Allow 30 seconds - 1 minute.
3. Have students draw a picture of their ideal bushland setting. They can write a poem or short story to go with their drawing to help illustrate their value of the bush.
4. In small groups or pairs, students brainstorm why they think bushland is important. Record ideas on paper and merge with another pair or group to share ideas and add to individual lists.
5. Discuss with your class how these ideas can be grouped into four categories - environmental, economic, cultural and aesthetic. Provide your class with descriptions for each of these different categories. Divide a sheet of AO paper into four sections with one of the headings for each.
6. Ask students to volunteer ideas from their list and suggest which heading they should be written under. You can add your own ideas to the list to encourage student participation.

PART TWO: How does Phytophthora dieback affect plants?
In class activity. Allow 1-2 hours.

Required Resources:

- Plastic straws.
- Pins.
- Cups and water.
- Timers.

Teacher Preparation:

- Read Teacher Background Information in Phytophthora Dieback lesson plan.
- Familiarise yourself with how Phytophthora dieback affects native plants in the Esperance Region. For additional information about diagnosis and treatment, the Dieback Working Group website (Dieback Working Group, 2016) is a comprehensive resource for Phytophthora dieback and contains links to further education activities and publications. The link to the website can be found in the reference section.
- Familiarise yourself with the different species of native plants that are affected by Phytophthora dieback. Appendix 2 contains an illustrative poster with lists of susceptible plants and Appendix 3 and 4 contain photos of bushland affected by Phytophthora dieback and healthy bushland.
- Prepare for the "Phytophthora dieback - how does it kill plants" experiment. This hands-on experiment stimulates the mechanism by which plants die.

Procedure

1. Introduce your class to Phytophthora dieback and its deadly effect on Esperance bushland areas. Discuss the different plant species that are affected by Phytophthora dieback and the national parks and bushland reserves across Esperance that are at threat.
2. Compare images of dieback affected bushland environments with images of healthy bushland areas.

Discuss the visible signs of Phytophthora dieback.

3. Explain to the class that they will be simulating the mechanism by which plants die from Phytophthora dieback. Give each student a healthy straw (root) and have them suck up 250 ml of water. Record the time it takes for the last person to finish.
4. The root is then infected with dieback and tissues are rotted away (pierce the straw many times with a pin above the water line in the cup). Students are challenged to try and suck up the same amount of water. Compare the time taken.
5. Students write a personal response to the infection by Phytophthora dieback as though they were the plant struggling to get enough water.

5.2 ACTIVITY TWO: Protecting against Phytophthora dieback
In class activity. Allow 1.5 hours.

Overview:

In this activity, students will further develop their understanding of how Phytophthera dieback threatens important areas of native biodiversity and how these areas can be protected through ongoing management.

Required Resources:

- Smartboard or other multimedia and internet access for viewing of "Stop the Rot".
- A0 Paper for recording information.
- One sheet of A0 paper per group of 3 - 4 students.
- Crayons/ textas/ coloured pencils.

Teacher Preparation

- Read Teacher Background Information in Phytophthora Dieback lesson plan. Refer to the Dieback Working group website for additional information.
- Watch the Armadale Primary School Performance "Stop the Rot", accessible on You Tube at: https://www.youtube.com/watch?v=ADoYXtTm1LQ

Procedure:

1. Watch with your class the Armadale Primary School Dieback Performance "Stop the Rot" You Tube video.

The storyline:
A peaceful Jarrah forest scene is invaded by horse riders and motorbike riders who spread dieback spores. These move to and infect the Jarrah trees, leading to their death. Children from a picnicking family are distressed by the dead trees and ask scientists for their help. A solution is found and the Dieback Busters inject the remaining trees. Another attempt at infection by the dieback spores is successfully repelled. All the characters join a rally spreading the message about 'Stopping the Rot' while the animals and tree spirits rejoice as some children plant a dieback resistant tree.

The characters:
Tree Wraiths or Spirits: The life force of our beautiful jarrah trees living in harmony with the environment until dieback is spread.

Animals:
Kangaroos, dingo, wedge tailed eagle, and small mammals, using the forest as their home and food source.

Horse Riders:

Peacefully using the forest but unaware that their horses hooves are spreading dieback spores.

Motorbike Riders: Shattering the peace of the forest for their own enjoyment and also unknowingly spreading dieback.

Woodchoppers: Representing both family and commercial woodchoppers but unknowingly spreading the dieback on their wheels of their vehicles. Watch for the dieback spores rolling in with their entrance.

Dieback Spores: The black hooded figures with hot red bits of mycelium growing on them that roll in with the horses hooves and the wheels of the motorbikes and woodchoppers' trailer.

Family: Out for a picnic enjoying the forest until the children see the dead trees. They alert their parents who call the scientists to solve the problem.

Scientists– Stir, shake, mix and experiment until they come up with a chemical to inject into the trees.

Dieback Busters: Your typical hero wearing dieback injecting back packs, they are given the solution by the scientists and sent off to inject it into the trees, making them able to repel the dieback attack.

Important messages:

Even though the dieback organism is represented as 'evil' by its colours, the music and lighting change, we need to help the students understand that it is not really evil. It is just trying to live, grow and survive as all organisms do. Human activity brought the pathogen into Australia, a new area, from its natural environment overseas by the early settlers. Attached to soil on the roots of plants before quarantine was enforced, it now spreads very quickly by human activities.

2. Discuss as a class the different characters in the video. Centre your discussion around the following ideas:
   - What would each character be feeling?
   - Do they actually know they are spreading dieback?
   - Do they care?
   - How would the scientists feel when they saw that their solution worked?
   - Is it the dieback organism's fault that trees were dying?
3. Divide students into small groups and have them brainstorm management ideas for protecting bushland reserves and national parks from the threat of Phytophthora dieback. Each group shares their ideas with the class, record ideas on A0 paper.
4. Students create a colourful informative poster encouraging the community to stop the spread of Phytophthora dieback and using bushland wisely. Display these posters around the school.

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Kookaburra

Kookaburra sits in the old gum tree
Merry merry king of the bush is he
Laugh kookaburra
Laugh kookaburra
Gay your life must be

Fur And Feathers by A. B. 'Banjo' Paterson

The emus formed a football team
Up Walgett way;
Their dark-brown sweaters were a dream
But kangaroos would sit and scream
To watch them play.
"Now, butterfingers," they would call,
And such-like names;
The emus couldn't hold the ball
— They had no hands — but hands aren't all
In football games.
A match against the kangaroos
They played one day.
The kangaroos were forced to choose
Some wallabies and wallaroos
That played in grey.
The rules that in the west prevail
Would shock the town;
For when a kangaroo set sail
An emu jumped upon his tail
And fetched him down.
A whistler duck as referee
Was not admired.
He whistled so incessantly
The teams rebelled, and up a tree
He soon retired.
The old marsupial captain said,
"It's do or die!"
So down the ground like fire he fled
And leaped above an emu's head
And scored a try.
Then shouting, "Keep it on the toes!"
The emus came.
Fierce as the flooded Bogan flows
They laid their foemen out in rows
And saved the game.

On native pear and Darling pea
They dined that night:
But one man was an absentee:
The whistler duck — their referee —
Had taken flight.

Bushland Poems For Upper Primary School

Bell Birds by Henry Kendall

By channels of coolness the echoes are calling,
And down the dim gorges I hear the creek falling;
It lives in the mountain where moss and the sedges
Touch with their beauty the banks and the ledges.
Through brakes of the cedar and sycamore bowers
Struggles the light that is love to the flowers.
And, softer than slumber, and sweeter than singing,
The notes of the bell-birds are running and ringing.
The silver-voiced bell-birds, the darlings of day-time!
They sing in September their songs of the May-time;
When shadows wax strong and the thunder-bolts hurtle,
They hide with their fear in the leaves of the myrtle;
When rain and the sunbeams shine mingled together,
They start up like fairies that follow fair weather;
And straightway the hues of their feathers unfolden
Are the green and the purple, the blue and the golden.
October, the maiden of bright yellow tresses,
Loiters for love in these cool wildernesses;
Loiters, knee-deep, in the grasses, to listen,
Where dripping rocks gleam and the leafy pools glisten:
Then is the time when the water-moons splendid
Break with their gold, and are scattered or blended
Over the creeks, till the woodlands have warning
Of songs of the bell-bird and wings of the Morning.
Welcome as waters unkissed by the summers
Are the voices of bell-birds to thirsty far-comers.
When fiery December sets foot in the forest,
And the need of the wayfarer presses the sorest,
Pent in the ridges for ever and ever
The bell-birds direct him to spring and to river,
With ring and with ripple, like runnels whose torrents
Are toned by the pebbles and leaves in the currents.
Often I sit, looking back to a childhood,
Mixt with the sights and the sounds of the wildwood,
Longing for power and the sweetness to fashion,
Lyrics with beats like the heart-beats of Passion;—
Songs interwoven of lights and of laughters
Borrowed from bell-birds in far forest-rafters;

So I might keep in the city and alleys
The beauty and strength of the deep mountain valleys,
Charming to slumber the pain of my losses
With glimpses of creeks and a vision of mosses.

Dusk Descends by Elizabeth Squires

dusk descends upon the Oz bush landscape
the sun slowly reclines westward
cattle and sheep make for nightly camps
the faint sound of birds are heard
gum trees cast last shadows
o'er the land a hush
day closes
then to
night
stars
aplenty
fill the sky
the scent of earth
flows on the soft breeze
so calming those night hours
the country is serene and still
how fortunate we who live here
in a place which is like paradise
as the moon sails across the bushland skies

Goodly Air by Elizabeth Squires
a peaceful mood is within the country's chair
rain drops falling dispersing their fare
the bushland no more in despair
a quenching drink on soils bare
terrain out of dry lair
getting a wet share
lands now repair
moist the care
goodly
air

biodiversity

Dieback — the Wildflower Killer

Over 40% of plant species in south western Australia are killed by Phytophthora dieback. The below plant families and genera are ALL impacted by Phytophthora dieback.

Proteaceae	Myrtaceae	Epacridaceae	Other
Adenanthos	Agonis	Andersonia*	Allocasuarina
Banksia*	Beaufortia	Astroloma*	Anarthria
Conospermum	Calothamnus	Leucopogon*	Boronia
Dryandra	Calytrix	Lysinema*	Conostylis
Franklandia	Eremaea	Monotoca*	Dampiera
Grevillea	Eucalyptus	Sphenotoma*	Dasypogon
Hakea	Hypocalymma	Styphelia*	Daviesia
Isopogon*	Kunzea		Eutaxia
Lambertia*	Melaleuca		Gastrolobium
Persoonia*	Regelia		Hibbertia*
Petrophile*	Scholtzia		Hovea
Stirlingia*	Thyptomene*		Jacksonia
Synaphea	Verticordia*		Lasiopetalum*
Xylomelum			Latrobea
			Macrozamia
			Oxylobium
			Patersonia
			Phlebocarya
			Xanthorrhoea
			Xanthosia

* many species in these genera are severely affected

Appendix 3: Images of Phytophthora dieback affected vegetation

Appendix 4: Healthy native vegetation

CATCHMENT HEALTH

1. OVERVIEW

Students will understand what a catchment is and the effects of human activity on water quality and quantity.

2. LINKS TO AUSTRALIAN CURRICULUM

STRAND	SUB-STRAND / KEY ORGANISING IDEAS
ENGLISH Literacy	Interpreting, analysing and evaluating Texts in context
SCIENCE Science as a human endeavour	Nature and development of science Use and influence of science
Science inquiry skills	Communicating Evaluating Planning and conducting Processing and analysing data and information
Science understanding	Biological sciences Earth and space sciences

3. OBJECTIVES

Students will:

- Understand the role of a catchment and the importance of catchment health, and
- Participate in the modelling of a catchment and the identification of threats to water quality.

TOPICS
Catchments
Catchment health
Threats to catchment health
Modelling catchments

PHASES OF LEARNING
3-6, 7-9

SITE (LOCATION)
Classroom

ACTIVITIES
1.1 In class (1 hr)
1.2 In class (1.5 hrs)
2.1 In class (1.5 hrs)
2.2 In class (1 hr)

MATERIALS
- AO paper
- Copy of the river catchment image
- Two large rectangular containers
- Soil
- Watercress seeds
- Wheat, canola and barley seeds
- Sieve
- Spray bottle
- Cardboard to model houses, animals and other catchment features
- Scissors
- Butter containers
- Watering can
- Large clear container of water
- Pollutants for the story
- Computers or iPads for each student, or group of students if working together

4. TEACHER BACKGROUND INFORMATION

4.1 What is catchment health?

A catchment is an area where water is collected by the natural landscape. Within a catchment, water flows down the landscape until it reaches the lowest point and eventually flows into a creek, river, lake, wetland, ocean, or into the groundwater system (Australian Museum 2015 a). Along the way, some water is absorbed into the ground, some evaporates and some is used by plants. The remaining water that continues to run over the surface of the land is known as surface runoff. Water can easily move from one place to another, even through the tiniest gaps in the soil, so in a catchment anything that happens in one place can eventually affect other areas of the catchment (Water Corporation, 2016).

The natural water cycle is a continuous movement of water between the land, oceans, waterways and the atmosphere. As water moves through the cycle, it changes state from liquid (rainwater, seawater) to gas (water vapour) and back to liquid (Melbourne Water, 2016). Liquid can also freeze and become solid (ice or snow). This natural process removes some of the water's impurities, constantly refilling Earth's fresh water supplies – it is our planet's way of recycling water (Melbourne Water, 2016).

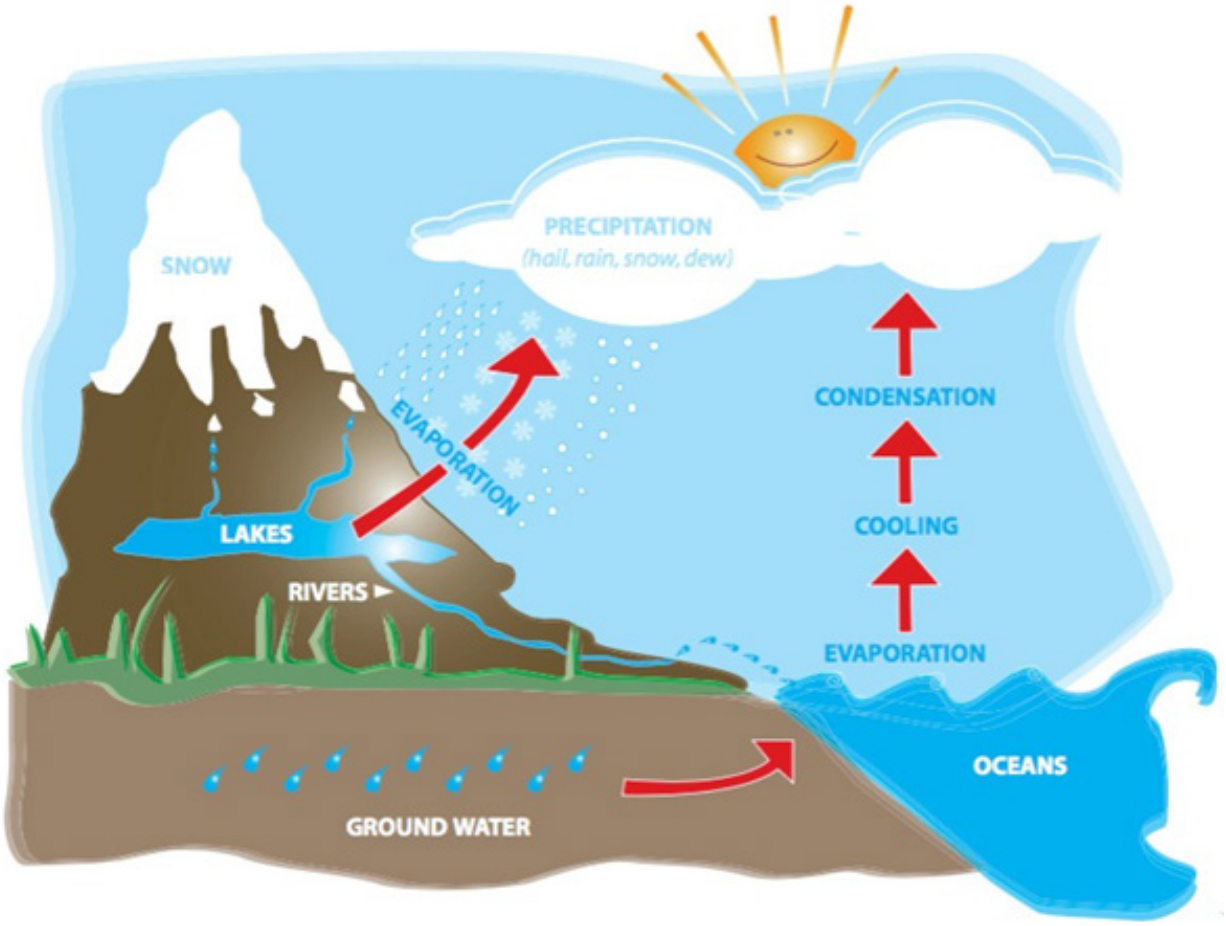


Figure 1: The Natural Water Cycle (South East Water, 2016).

A catchment is the scale on which many parts of the landscape work. The soil, plants, animals and water all function together in a catchment – anything that affects one of these will also have an impact on the others (ABC Science, 2016). A healthy catchment is one that is still able to function as a catchment should. It should be able to filter and clean water as it flows overland and seeps through the ground, and there should be lots of opportunities for water to seep into the ground so that it can be used by plants (Georges River Catchment Council, 2016). A well-managed catchment provides healthy waterways as habitat for animals and plants, a reliable source of clean water and unspoilt natural areas for recreation (Australian Museum, 2016 b). Catchments are a part of our life support systems, and they support the lives of all plants and animals (ABC Science, 2016).

Over the last 200 years land has been cleared for farming, mining, building towns and cities, changing catchments which had been in equilibrium for thousands of years. All this activity has resulted in damage to the health of our catchments, including loss of biodiversity, sedimentation and salinisation of rivers and the spreading of weeds and pests (ABC Science, 2016). The broad extent of catchment and water quality decline in Australia has been caused by a lack of understanding about the complexities of water catchments.

Catchment areas vary significantly in size, from small urban sub-catchments that feed larger systems, to huge catchments such as the Murray Darling Basin that spans three states (ABC Science, 2016). In Albany, the King George Sound catchment area consists of two main catchments: Oyster Harbour which is over 300,000 ha and Princess Royal Harbour which is substantially smaller at only 8,000 ha (South Coast NRM, 2011). Land management in both these catchments has a direct effect on the quality of water in these ecologically significant waterways.

4.2 Catchment health in Australia and the Esperance Region

European settlement has significantly altered Australia's natural landscape, and with it, Australia's biodiversity. About 90% of native vegetation in the eastern temperate zone has been removed for agriculture, industry, transport and human habitation. About 50% of Australia's rainforests have been cleared and the proportion of Australia covered by forest or woodland has been reduced by more than one third (Bush Heritage Australia, 2016). As land cover is crucial to land condition, land clearing exerts significant pressure on soil health.

In 2008, an assessment was made of the overall health of Australia’s more intensively used catchments (Land & Water Australia, 2016).

The assessment looked at land, water and biodiversity in each catchment, including problems such as salinity, erosion, sedimentation, pesticide use, pollution, roads, native tree cover, human population and pests.

The survey, done by the National Land and Water Resources Audit, found:

- 5% of catchments are in the poorest condition
- 15% are in low range condition
- 50% are in mid-range condition, and
- 30% are in better condition.

These stats suggest that the condition of 70% of Australia’s most populated catchments is merely average or worse than average (ABC Science, 2016).

The South Coast Region covers approximately 8.6 million hectares, of which most is classified as agricultural land. Primary production, including agriculture and forestry, contribute strongly to the region’s economy and social fabric but faces some significant threats if major efforts are not made to develop and manage more sustainable farming systems (South Coast NRM, 2011). Soil stability is essential to avoid land degradation, healthy soils support the Esperance Region’s biodiversity and it’s land based primary production. Soil health also contributes to sustainable waterways and marine environments by avoiding erosion, nutrient export and sedimentation (South Coast NRM, 2011).

The Esperance Region contains a suite of coastal nature reserves and national parks including Jerdacuttup Lakes and Lake Shaster nature reserves and the Stokes, Cape le Grande, and Cape Arid national parks. These areas of native vegetation play a significant role in protecting catchment health and their waterways (South Coast NRM, 2011). The Region is also characterised by a broad network of ecologically significant wetlands and river systems. Two wetland suites, and part of the Lake Muir system, are identified as Wetlands of International Significance (under the RASMAR Convention) (South Coast NRM, 2011). The Lake Warden wetland system has a catchment size of approximately 212 000 hectares, of which more than 95% is cleared, 80% of which is cleared agricultural land (Esperance Regional Forum, 2016 a). The Lake Gore wetland system, whose catchment covers approximately

82 000 hectares, has less then ten percent of its original native vegetation remaining. The extensive clearing of remnant vegetation, changes to natural land forms, current and past farming practices have placed both these wetlands systems under considerable stress from inundation, eutrophication, sedimentation and salinity (Department of Environment and Conservation, 2009 a).

4.3 Threats to catchment health in the Esperance Region

Widespread clearing and altered land use resulting in changed hydrology and increased salinity levels are a major threat to healthy functioning catchments (South Coast NRM, 2011). Land clearing is the number one cause of dryland salinity. When native vegetation is removed the rain moves down to the water table, causing it to rise and force the soil salt to the surface. This situation is almost impossible to reverse and ruins not only the biodiversity of the Esperance Region but devastates the agricultural value of the land (The Wildnerness Society, 2016).

Removal of vegetation also leaves soil bare and vulnerable to erosion. Excess sediment can be damaging to the ecological health of waterways and reduce their environmental, social and cultural values (Department of Water, 2016). Mobilised coarse sandy sediment tends to accumulate in areas of slow-flow and may smother bottom-dwelling organisms and their habitats. Deep permanent river pools, that are valuable habitats for aquatic fauna and refuges for wildlife during summer and drought, become filled by course sediments (Department of Water, 2016).

Climate change poses a considerable threat to catchment health in the Esperance Region. Increases in unseasonal, episodic rainfall events have exacerbated the affects of catchment clearing, resulting in an altered hydrological regime in ecologically significant wetlands Lake Warden and Lake Gore. Changes to the hydrological regime have caused a reduction in exposed shore zone and wading habitat for waterbirds. The altered hydrological regime has also impacted on vegetation where the extent and duration of inundation has exceeded natural thresholds, resulting in death of riparian vegetation (Department of Environment and Conservation, 2009 b). Projections of future changes in climate include increasing temperatures and temperature extremes, increasingly severe droughts, rising sea levels, decreasing rainfall, regional flooding and reduced water availability (Office of Environment & Heritage, 2016).

5. ACTIVITIES

5.1 ACTIVITY ONE: Understanding catchment health

This activity has two parts. In this activity, students will learn about the importance of catchment health. Students will model a catchment and investigate the flow of water. Students will also learn about the impact catchment health has on the quality and quantity of water in rivers and wetlands.

PART ONE: What is a catchment?
In class activity. Allow 1 hour.

Required Resources:

- AO paper
- Copy of the river catchment image

Teacher Preparation:

1. Read Teacher Background Information in Catchment Health lesson plan.
2. Consider how different plants and animals in the upper, mid and lower catchment areas rely on catchment health for habitat protection and water supply. Appendix 1 from the water quality education program contains case studies of important wetlands and river systems in the Esperance Region.

3. Print out the image of a river catchment from Appendix 1 and display it in the classroom.

Procedure:

1. Introduce your class to the concept of a healthy catchment, explain how catchments filter water and provide habitat to plants and animals.
2. Referring to the image of a river catchment, discuss with your class the different features you would find in a local catchment. List these as either natural (such as plants, animals, hills and waterways) or artificial/ human made (such as buildings, roads, cars and boats). Explain that over 200 years ago, catchments were covered in native vegetation and waterways were near pristine. Today, rainwater travels past all these different features in a catchment therefore it's important to protect our water resources from pollution.
3. Discuss as a class the different users and uses of a catchment and the potential threats to water quality. In small groups, students select a catchment use (farming, market gardening, commercial use, recreation fishing, motorists) to investigate and identify:

   - How they use the water in the catchment
   - What impact the users might have on the catchment and water quality (both positive and negative impacts)
   - How they could modify their actions to improve the health of the catchment.

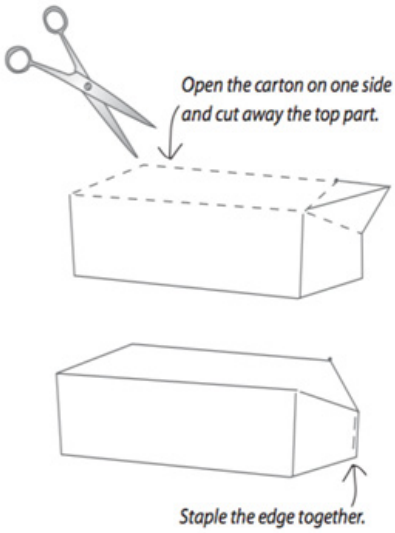
PART TWO: Modelling a catchment environment (adapted from Waterwatch Australia, 2016)
In class (our outside) activity. Allow 1.5 hours.

Required Resources:

- Two litre milk or juice cartons per small group of students OR
- Two large rectangular containers
- Soil
- Watercress seeds
- Wheat, canola and barley seeds
- Sieve
- Spray bottle
- Cardboard to model houses, animals and other catchment features
- Scissors
- Butter containers
- Watering can

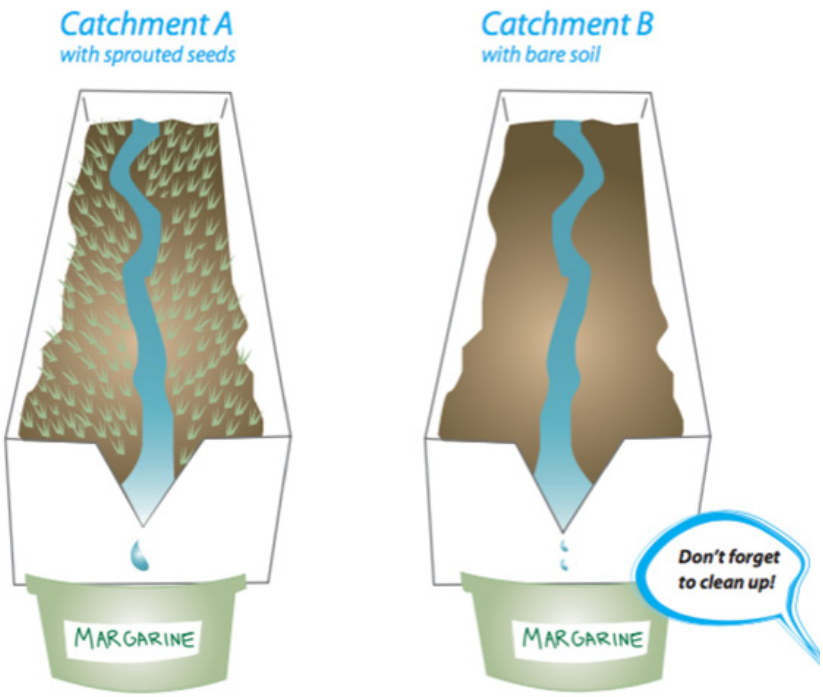
Teacher Preparation:

- Revisit how a healthy catchment functions to support the different elements of our environment. Background information is provided in Section 4 of this lesson plan.
- Decide whether this activity will be carried out in small groups using cardboard cartons or as a class using two large rectangular containers. If working in small groups you will need a large sunlit area to store the containers while they grow.
- Prepare the materials needed by your class to carry out the modelling of different catchments. If students are participating in small groups, you will need two cartons per group of 3 - 4 students. Cut open the top section of the 2 litre cartons, cardboard cartons are preferable, but plastic can also be used.
- If the modelling activity is to be carried out as a whole class activity you will need two large rectangular containers, a plastic drum cut in half will be perfect.



Procedure:

1. Divide students into groups and assign two containers to each group, or set up the two large containers at the front of the class. Explain to your class you will be modelling two different catchments to illustrate how water flows through the landscape. One catchment has trees, shrubs and crops, the other has bare ground.
2. Start the experiment by filling containers with soil. Shape some hills and a river bed in each container, you may need to dampen the soil to do this. Set aside one container and in the other, design areas in the upper catchment for native trees and shrubs and in the lower catchment for farming land. Using a sieve, gently sift a thin layer of soil where you will be planting the seeds. Plant watercress seeds for the native trees and wheat, barley and canola on the farming land. Sprinkle the seeds onto the soil and cover them with another layer of sifted soil. Water using a fine spray.
3. Have students design and cut out model houses, farm animals and buildings. Place these in both the catchment containers.
4. Store the containers in a warm sheltered position and keep the soil moist. When the seeds have germinated you will be able to go on with the next stage of your investigation.
5. Once the seeds have sprouted, incline the two containers to represent a slope. Place a butter container at the base of each catchment. Sprinkle the same amount of water over each catchment and measure the time it takes for the water to flow into the container at the base. Measure the amount of water in the containers.



	Catchment A	Catchment B
Water volume at start		
Water volume at finish		
Time taken		

6. Discuss the results, which catchment is more likely to have soil erosion problems?

5.2 ACTIVITY TWO: Investigating catchment health

Overview:

The activity has two parts. In this activity, students will develop an understanding of catchment processes and the threat of different catchment uses on water quality.

PART ONE: How does catchment health affect our waterways?
In class activity. Allow 1 hour.

Required Resources:

- Large clear container of water
- Pollutants for the story

Teacher Preparation:

- Read through the story of an "Unhealthy Catchment" adapted from the Department of Water Ribbons of Blue Program (2007). See the procedures section for the story and the activities undertaken by students during narration.
- Prepare a large clear container of water to be placed at the front of the classroom. This will be used to illustrate water in a stream.
- Prepare the pollutants needed for the story in small clear containers. Assign students to each water pollutant.

Soil = cocoa powder
Pesticides = water and blue food colouring
Herbicides = water and red food colouring
Fertiliser = water and green food colouring
Manure = chocolate sprinkles
Salt = table salt
Fishing line = fishing line
Rubbish = glad wrap
Cigarette butt = brown paper
Oil = kitchen oil
Litter = plastic bottle
Detergent = dishwashing detergent

Procedure:

1. Students sit with their container of pollution in front of them, a large clear container of water is placed at the front of the class. As each pollutant is mentioned in the "Unhealthy Catchment" story, students who have that pollutant in their container are invited to come to the front and pour it into the container of water.

Unhealthy Catchment Story:
The story begins in the upper parts of a catchment in Esperance where pristine rain water runs off the hills into a stream. As rain travels down this stream, other streams and creeks join up along the way until the water reaches Lake Warden.

As the water continues down the stream there are farm animals that use the stream for drinking. Each time they step near the banks, soils fall into the banks and as it rains the river banks are gradually eroded.
Add the soil to the water.

The soil falling into the water holds many fertilisers used by farms for healthy pastures and the pesticides and herbicides they use to protect their crops from pests and weeds.
Add the pesticides, herbicides and fertilisers to the water.

Large animals in the area leave their manure, which runs off into the water.
Add the manure to the water.

Further down the stream there is a lake that has a high water table and is very salty due to the heavy clearing that has occurred in the area.
Add the salt to the water.

As the stream travels around a bend there are people fishing, they get snagged and their fishing line is left in the river.
Add the fishing line to the water.

People are having a picnic near the stream, some rubbish blows off the table and a person's cigarette butt rolls into the water. Some dogs have taken off for a wander and left some droppings near the river, it rains and the droppings fall in.
Add the rubbish, fishing line and dog droppings into the water.

As it gets closer to the town there are parks and ovals where gardeners use sprays and fertilisers to keep the grass green and limit the weeds.
Add the pesticides, herbicides and fertilisers to the water.

Water run-off from houses, drains and roads contain dirt, oil, litter and detergents which contain phosphates. Phosphates cause algal growth which uses up the oxygen in the water, causing some aquatic animals to die.
Add soil, oil, litter and detergent to the water.

When this water reaches the wetland system it is salty, full of sedimentation, rubbish, oil, chemicals and detergents. END

2. Discuss as a class the different threats to water quality and how the community in the catchment can work together to protect the quality of water flowing into Esperance waterways. Threats to water quality will be covered in detail in the water quality education program, so the aim is to touch on these issues rather than explore them thoroughly.

PART TWO: Catchment detox challenge
In class activity. Allow 1 hour.

Required Resources:

- Computers or iPads for each student, or group of students if working together

Teacher Preparation:

1. Familiarise yourself with the Catchment Detox Challenge, read through the tutorial for a step by step lesson on how to play the interactive game. The link to Catchment Detox is on the ABC Science website: http://www.abc.net.au/science/catchmentdetox/files/home.htm

Procedure:

1. Discuss as a class the challenge of managing a healthy catchment, with climate change, increased demand for water and environmental problems putting our waterways under stress. Explain that the Catchment Detox Challenge gives students an idea of just how difficult it is to manage a river catchment.
2. Students undertake the detox challenge individually or in small groups. Explain the process of the game and have each student run through the tutorial, answering any questions before the challenge is started. Assistance may be required as students work their way through the challenge, encourage them to problem solve and investigate solutions.
3. Once everyone has completed the Catchment Detox Challenge, have students share their experiences in a class discussion.

VOCABULARY

Catchment: The land area which drains into a particular waterway and which is a natural topographic division of the landscape. It includes "end of catchment", where catchments join other rivers or estuaries.

Ecosystem: A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.

Estuarine: A semi-closed or periodically closed coastal body of water in which the aquatic environment is affected by the physical and chemical characteristics of both freshwater and marine systems.

Land use: Land use describes the activities that occur on land, such as agriculture, energy production, human settlements, transport, forestry, mining and conservation.

Riparian: Plant habitats and communities along the river margins and banks are called riparian vegetation.

Salinity: The accumulation of excessive salts in land and water at sufficient levels to have an impact on human and natural assets (plants, animals, aquatic ecosystems, water supplies, agriculture or infrastructure).

Turbidity: is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air.

Sedimentation: the accumulation of sand and dirt that settles in the bottom of waterways.

Water quality: Refers to the chemical, physical, biological, and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose.

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Appendix 1. (Department of Environment, Water and Natural Resources 2016).

WATER QUALITY

1. OVERVIEW

Students will look at the physical and chemical characteristics of water and understand the importance of water quality in wetland and river systems.

2. LINKS TO AUSTRALIAN CURRICULUM

STRAND	SUB-STRAND / KEY ORGANISING IDEAS
MATHEMATICS Statistics and probability	Data representation and interpretation
SCIENCE Science as a human endeavour	Nature and development of science Use and influence of science
Science inquiry skills	Questioning and predicting Planning and conducting Processing and analysing data and information
Science understanding	Biological sciences

3. OBJECTIVES

Students will:

- Learn how to collect water quality information, including temperature, colour, suspended sediment, dissolved oxygen and salinity.
- Participate in collection of water samples and recording of water quality.
- Understand how water quality affects animals, plants and humans that rely on the water source.

TOPICS
Water quality
Testing
Sampling

PHASES OF LEARNING
3-6, 7-9

SITE (LOCATION)
Classroom
Local environment

ACTIVITIES
1.1 In class (1 hr)
1.2 In class (1 - 2 hrs)
2.1 Local waterbody (2 – 3 hrs)

MATERIALS
- One sheet of A0 paper per group of 3 - 4 students
- Crayons/ textas, coloured paper, glue
- Copy of "Wunambi the Water Snake"
- A4 paper for drawing location maps.
- Student worksheets to record measurements.
- Textas/ crayons/ pencils.
- Clipboards.
- Sturdy shoes, water bottles, protective clothing.
- Water quality testing equipment

4. TEACHER BACKGROUND INFORMATION

4.1 What is water quality?

Water quality testing gives an indication of the health of a waterway. The term 'water quality' refers to the physical, chemical and biological characteristics of both water and sediment (Department of Water, 2016a). Water quality can be measured by collecting water samples for laboratory analysis or by using probes which can record data at a single point in time, or logged at regular intervals over an extended period (Department of Water, 2016b).

Water quality monitoring involves making observations and taking measurements that are analysed and reported to provide information and knowledge about catchments and waterways (Department of Water, 2016c). Monitoring changes in water quality helps to evaluate the impacts of management actions at the catchment level as well as prioritising on ground works and actions to improve waterway health. The physical characteristics of water that are monitored include temperature, colour, light and sediment suspended in the water. Chemical characteristics include dissolved oxygen, acidity (pH), salinity, nutrients and other contaminants. Biological characteristics include bacteria and algae (Department of Water, 2016 d).

4.2 Important water quality indicators

4.2.1 Salinity

Salinity is a measure of the content of salts in soil or water. Salts are highly soluble in surface and groundwater and can be transported with water movement. Large salt deposits are a natural feature of vast areas of the Australian landscape, stored deep in soils or as surface salt deposits and salt lakes. This natural distribution of salt in the landscape is referred to as 'primary salinity' (Department of the Environment, 2016 a).

In normal circumstances, the deep roots of native plants absorb most water entering the soil before it reaches the salt contained in groundwater below the plant root zone. However, widespread vegetation clearance, poor land use, irrigation and industrial practices have made it easier for salt to be transported to the soil surface or to waterways. The additional salt from these altered land use and management practices is referred to as 'secondary salinity' (Department of the Environment, 2016).

4.2.2 Turbidity

Turbidity is a measure of the cloudiness of water. Turbid water does not look clear; it looks murky or muddy due to the solid material that is suspended within the water. Water becomes turbid when it contains particles which have not dissolved. The particles can be of varying sizes from very fine ones which hang as a haze in the water to coarse particles that are large enough to settle over time, if the water is still. Water may also be coloured, in this case the colour is due to the presence of brown tannin from plant material. The presence of colour does not necessarily mean the water is turbid as often such waterways are quite clear, but the colour makes measuring turbidity accurately more difficult (Waterwatch Australia, 2016).

4.2.3 Eutrophication

Eutrophication is the enrichment of an ecosystem with chemical nutrients, typically compounds containing nitrogen, phosphorus, or both. Runoff from agriculture and development, pollution from septic systems and sewers, and other human-related activities increase the flux of both inorganic nutrients and organic substances into aquatic and coastal marine ecosystems (Science Daily, 2016).

4.2.4 pH

pH is a measure of the acidity or alkalinity of water. The pH scale ranges from 0 to 14, where 7 is classed as neutral, 0 to less than 7 is acidic and greater than 7 to 14 is alkaline or basic. Rainwater usually has a pH value between 5.5 and 6.0. Natural sea water has a pH of 8.2. The best pH level for most organisms in Australian freshwater waterways is pH 6.5 to pH 8.2. Changes in pH outside this normal range can cause a reduction in

species diversity, with many of the more sensitive species disappearing (Waterwatch Australia, 2016).

4.2.5 Water temperature

The main effect of water temperature on the environment is related to oxygen in the water. The amount of oxygen that water can hold decreases as the temperature of the water increases. Temperature also affects the metabolic rate of aquatic animals, rates of development, breeding cycles, mobility, migration patterns and the sensitivity of organisms to toxins, parasites and disease (Waterwatch Australia, 2016).

4.3 Water quality in Australia and the Esperance Region

Managing Western Australia's water resources requires a significant focus on water quality. The Department of Water routinely measures the quality of groundwater and surface water across the state while the Department of Parks and Wildlife monitors water quality in wetlands. This information helps to protect important aquatic ecosystems and the social and economic services they provide to our community (Department of Water, 2016 a).

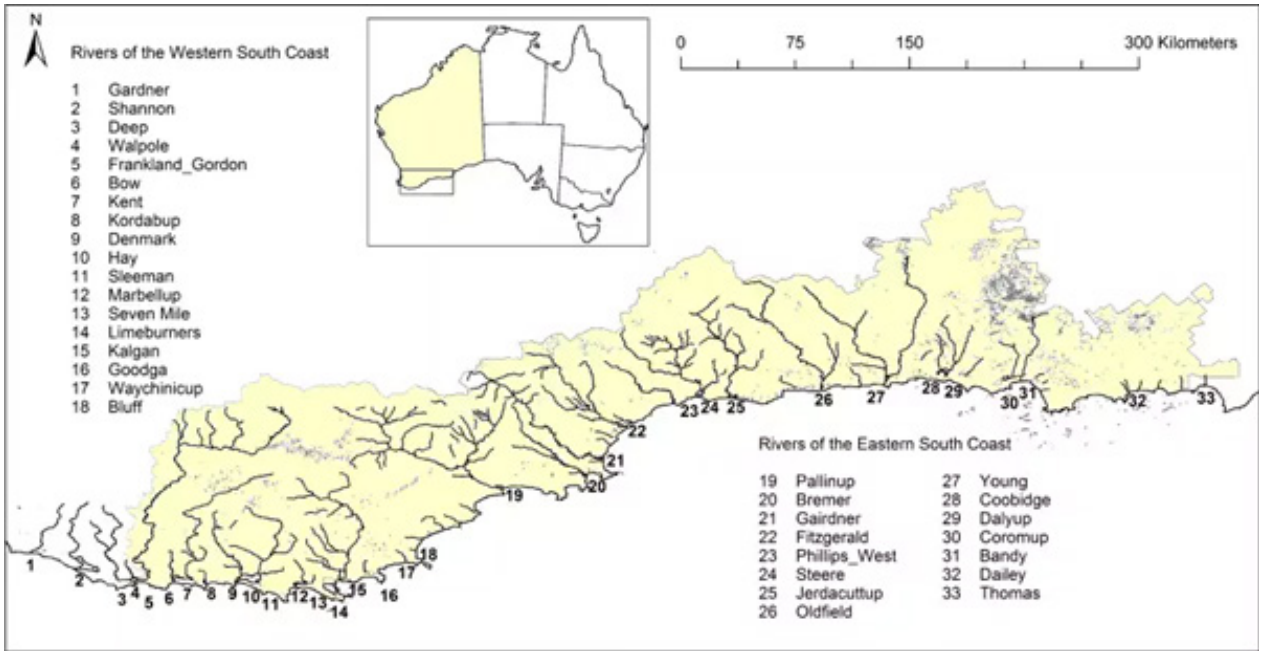

Figure 1. Ecologically valuable waterways of the South Coast Region (Cook et al, 2008)

The Esperance Region is characterised by a broad network of ecologically significant wetlands and river systems as shown in figures 1 and 2. Eleven of these wetland systems are listed in the Directory of Important Wetlands in Australia (Environment Australia, 2001) and fifteen systems are on the Register of the National Estate (South Coast NRM, 2011). Two wetland suites, Lake Warden and Lake Gore, and part of the Lake Muir system are identified as Wetlands of International Significance (under the RAMSAR Convention) (South Coast NRM, 2011). Seven river systems in the Esperance Region, from Young River in the west through to Thomas River in the east, make up part of the Eastern South Coast aquatic bioregion (Cook et al, 2008).

These diverse waterways are home to a number of endemic macro invertebrate species, meaning they aren't found anywhere else in the world, and thousands of migratory birds. Managing the quality of both surface water and ground water in the Esperance Region is vital for protecting important ecosystems.

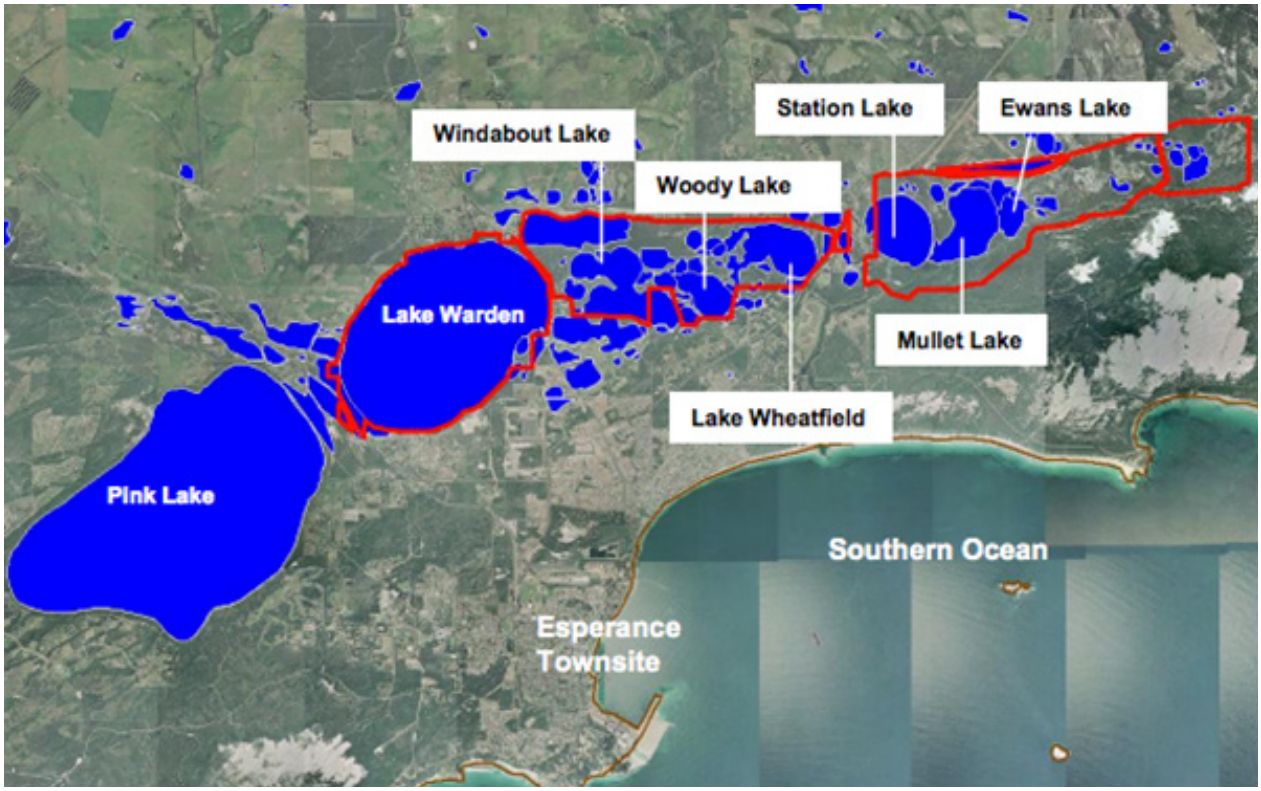

Figure 2: Lake Warden Wetland System (Department of Environment and Conservation, 2009 a).

The Lake Warden wetland system (as shown above in Figure 2) is situated in the Esperance Sandplain Biogeographic Region. The site is located in the Shire of Esperance, approximately 5 km north of the Esperance townsite and covers an area of 1,999 ha (Department of Environment and Conservation, 2009 a). The Lake Warden Wetland System was designated as a Wetland of International Importance under the RAMSAR Convention on the 7th January 1990. The RAMSAR Convention defines ecological character as "the combination of the ecosystem components, processes and benefits / services that characterise the wetlands at a given point in time". Lake Warden is an internationally recognised wetland system rich in flora and fauna. The wetland system provides significant waterbird habitat and refuge, and waterbird species listed under the international migratory agreements CAMBA, JAMBA, ROKAMBA and CMS have been observed at the site. The Lake Warden system is amongst the most important sites in south Western Australia for Hooded Plover, Banded Stilt and Chestnut Teal populations, and is an important drought refuge containing up to 20,000 waterbirds at one time. Other notable waterbird species include the Cape Barren Goose and the Fairy Tern. The Lake Warden Wetland System also comes under the Japanese and Chinese Migratory Bird Agreements (JAMBA & CAMBA) (Department of Environment and Conservation, 2009 a) (Esperance Regional Forum, 2016 a).

The Lake Warden Catchment, north of the wetland system, is the major source of surface and groundwater. Eighty per cent of the 212,000 ha catchment for Lake Warden is agricultural land and 95 per cent of this area is cleared. The extensive clearing of remanent vegetation, changes to natural land forms, current and past farming practices have placed the Lake Warden Wetland System under great stress from inundation, eutrophication, sedimentation and salinity (Department of Environment and Conservation, 2009 a).

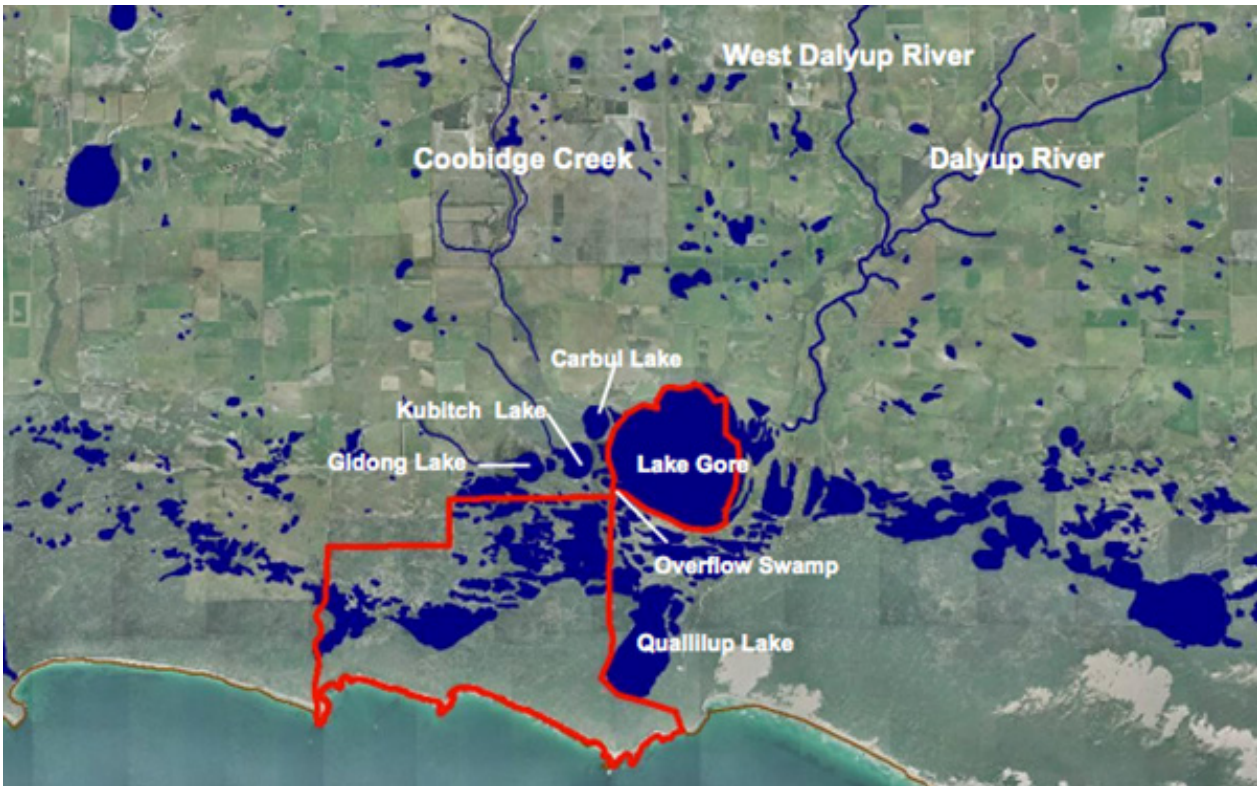

Figure 3: Lake Gore Wetland System (Department of Environment and Conservation, 2009 b).

The Lake Gore wetland system is situated in the Esperance Sandplain Biogeographic Region as shown in Figure 3. Lake Gore is the main receiving body of the surrounding catchments and covers an area of approximately 740 ha, depending on the extent of inundation. Permanent / seasonal lakes, flats, marshes and pools are fed partly by Lake Gore itself, and the seasonally flowing Coolidge Creek catchment. These wetlands cover an area of approximately 1,433 ha (Department of Environment and Conservation, 2009 b). The Lake Gore wetland system was designated as a Wetland of International Importance under the RAMSAR Convention on the 5th January 2001. The Lake Gore wetland system provides significant habitat for populations of Chestnut Teal, Australian Shelduck and Banded Stilt waterbirds (Department of Environment and Conservation, 2009 b).

The Lake Gore wetland system is the receiving body of the Dalyup catchment which consists of the Dalyup and West Dalyup Rivers and covers approximately 82,607 ha. The catchment is surrounded by the Coobidge Creek catchment to the west, Mortijinup Lake catchment to the south east and Coramup Creek catchment to the north east (Department of Conservation, 2009 b). Recent episodic unseasonal rainfall events have affected the hydrological regime of Lake Gore, with widespread flooding causing significant erosion and sediment deposition (Department of Conservation, 2009 b).

Stokes Inlet lies on the south coast of Western Australia, 80km west of Esperance. The Stokes Inlet covers a body of water 14 km2 when full and is fed by Lort and Young rivers creating a catchment area of more than 500 000 hectares and extending more than 100 km inland (Esperance Regional Forum, 2016 b). The inlet is normally closed from the ocean and breaches its sand bar infrequently. The occurrence of these bar breaks, while still infrequent, has increased since extensive land clearing and increased runoff in the catchment (Department of Water, 2016). Vegetated buffers along the Young and Lort river channels form a link between the coastal strip and the crown land to the north. These corridors form part of the South Coast Macro Corridor Network and have been recommended as part of the state system of protected areas. The catchments for Stokes Inlet, Lort River and Young River are more then 70 % cleared. As a result, the river system is under threat from salinity, eutrophication, water erosion and sedimentation (Esperance Regional Forum, 2016 b).

4.6 Threats to water quality in the Esperance Region

Catchment clearing and altered land use resulting in changed hydrology and increased salinity levels are major threats to water quality in river systems and wetlands of the Esperance Region. These land use threats can also be associated with increased erosion, sediment transportation, and altered turbidity and nutrient levels (South Coast NRM, 2011). Other threats include loss of riparian vegetation, nutrient enrichment, unmanaged recreational use, pollution from rural and urban land uses, over-extraction of limited freshwater and physical alteration to river banks, channels and floodplains (South Coast NRM, 2011).

Increases in unseasonal, episodic rainfall events have exacerbated the effects of catchment clearing, resulting in an altered hydrological regime in ecologically significant wetlands Lake Warden and Lake Gore. Changes to the hydrological regime have caused a reduction in exposed shore zone and wading habitat for waterbirds. The altered hydrological regime has also impacted on vegetation where the extent and duration of inundation has exceeded natural thresholds, resulting in death of riparian vegetation (Department of Environment and Conservation, 2009 b).

Monitoring the quality of water in wetlands and river systems is an important tool in managing catchment scale threats to aquatic biodiversity.

5. SUGGESTED ACTIVITIES

5.1 ACTIVITY ONE: Understanding water quality and habitat

Overview

This activity has two parts. In undertaking the activities students will develop an understanding of healthy waterways and learn about the different parameters that affect the quality of water. Students will also learn about the habitat of a waterway, and how everything living has a role to play in the ecosystem.

PART ONE: What is a waterway?
In class activity. Allow 1 hour.

Required Resources:

- One sheet of A0 paper per group of 3 - 4 students
- Crayons/ textas, coloured paper, glue
- Copy of "Wunambi the Water Snake"

Teacher Preparation:

- Read Teacher Background Information in Water Quality lesson plan.
- Familiarise yourself with significant waterways in the Esperance Region, background information is provided in Section 4 of this lesson plan. Further information on important wetlands and river systems can be found in the following resources: "Ecological Character Description of the Lake Warden System Ramsar Site, Esperance" (Department of Environment and Conservation, 2016 a), "Ecological Character Description of the Lake Gore System Ramsar Site, Esperance" (Department of Environment and Conservation, 2016 b) and "Benwenerup: A management plan for Stokes Inlet" (Department of Water, 2016). The links to download these publications is in the reference section.
- Purchase or loan the children's storybook "Wunambi the Water Snake" (O'Brien, 2005). This is a story of the time when the earth was young and the land was being created. It tells of a powerful and awesome water snake called Wunambi. The Wongutha People of the Eastern Goldfields area of Western Australia say that this huge creature roamed the earth and that the great tracks it made became creeks and rivers

we know today.

Procedure:

1. Introduce your class to the spiritual history of waterways in Western Australia. Read with your class the story of "Wunambi the Water Snake".
2. Ask students to close their eyes and imagine a waterway that they may have been to, such as a lake, wetland, creek or river. Ask them to imagine all the things that they would like to see in that environment. Allow 30 seconds - 1 minute.
3. Create a drawing of a healthy waterway environment. In small groups, students will collaboratively create a healthy waterway environment showing all the things they thought about. Guide students through a process of 'constructing' their picture using the following prompts:
   - Draw or use coloured paper for the water.
   - Add plants that live there.
   - Add animals that live there.
   - Add anything else that you think might be there.
4. Have students share their pictures and explain why they have included the different elements.

PART TWO: How does water quality affect habitat?
In class activity. Time required is dependent on activity selected.

Required Resources:

An equipment list is provided with each experiment in Appendix 2.

Teacher Preparation:

- Read Teacher Background Information in Water Quality lesson plan.
- Familiarise yourself with the definitions of water quality. Background information is provided in Section 4 of this lesson plan and Appendix 1 contains further information about water quality issues that are important to the Esperance Region, including causes of water quality decline and threats to habitat.
- Familiarise yourself with the water quality experiment/s you will conduct with your class. Appendix 2 contains details of the hands-on experiments for salinity and turbidity.

Procedure:

1. Undertake water quality experiment/s with your class in accordance with experiments outlined in Appendix
2. This important component allows students to experience firsthand how water quality can change and enables a discussion of the impacts on plants and animals.

5.2 ACTIVITY TWO: Water quality testing

Overview:

This activity has two parts. In this activity, students will observe the plants, animals and environment of a significant waterway in the Esperance Region. Students will undertake testing of water quality and be able to draw conclusions about waterway health.

PART ONE: Undertaking water quality testing
In field lesson. Allow 2 -3 hours (incorporating travel).

Required Resources:

- A4 paper for drawing location maps.
- Student worksheets to record measurements.
- Textas/ crayons/ pencils.
- Clipboards.
- Sturdy shoes, water bottles, protective clothing.
- Identify the equipment you will need to undertake specific water quality testing. Additional equipment that is required to collect water samples includes: water sampling bottles, sample containers, an extension pole (long arm sampler) and water sampler specimen containers. If you require scientific equipment for measuring salinity and turbidity, please contact South Coast Natural Resource Management for assistance in preparing for your activity.

EQUIPMENT	MEASUREMENT UNIT	PURPOSE
Turbidity tube	nephlometric turbidity units (NTUs)	clarity of water
Electrical conductivity (EC) meter	mS/ cm	salinity
Total dissolved solids (TDS) meter	ppm mg/ L	salinity
pH papers	0 - 14 scale	acidity/ alkalinity
Thermometer	degrees celsius	air and water temperature
Stopwatch	distance/ time	rate of flow

Teacher Preparation:

- Read Read Teacher Background Information in Water Quality lesson plan.
- Decide on a waterway in the Esperance Region that you would like to investigate with your class. Identify the water quality parameters that you will investigate at your chosen waterway.
- Print out the student work sheets from Appendix 3 that are used to record details of your chosen waterway. Choose the worksheet corresponding to the type of waterway you are investigating (upland river/ creek, lowland river/ creek or wetland).
- Print off and laminate copies of Sampling and Measuring Water Quality Parameters Procedures (Appendix 5) for quick reference in the field.

Procedure:

1. Visit your chosen waterway with a South Coast Natural Resource Management Officer to assist with water quality testing. If you are unable to take someone with you, you can preserve water samples for testing at a later date (see section 4).
2. Go for a walk around the waterway, observe with the class the physical landmarks, plants, animals and any other distinguishing features. Have each student draw a location map of your waterway.
3. Undertake water quality testing in groups and record the measurements for water quality parameters. Procedural guidelines for collecting and measuring water quality parameters have been adapted from the Junior Waterwatch Field Manual (Waterwatch NSW, 2016) and can be found in Appendix 5.
4. If you cannot do all the tests when the water sample is taken, some can be done later if samples are properly preserved. This is particularly useful if a Natural Resource Management Officer is unable to attend the excursion with you. Follow these guidelines set out below for preserving samples.

PARAMETER	PRESERVATION METHOD	MAXIMUM HOLDING TIME
pH	refrigeration	6 hours
Conductivity	refrigeration	30 days
Turbidity	none required	24 hours

PART TWO: Discussion of water quality results
In class session. Allow 1.5 hours.

Required Resources:

- A4 sheets of paper
- Textas/ crayons/ pencils

Teacher Preparation:

Familiarise yourself with the ANZECC water quality guidelines in Appendix 6. Revisit the information in Appendix 1 about the causes of water quality decline and threats to habitat in the Esperance Region.

Procedure:

1. Interpret with your class the results of water quality testing and discuss what they mean for water quality. Use small groups to interpret each water quality parameter and have them complete a drawing or written scenario to illustrate what happens when the parameter is too high, or too low.
2. Discuss as a class the human activity in the catchment area that affects water quality. Brainstorm in small groups the management actions that could be put into place to reduce the threats to water quality. Each group shares their ideas with the class.

VOCABULARY

Bioregion: An area of land which shares similar environmental, physical and climatic conditions and which contains characteristic ecosystems of plants and animals.

Catchment: The land area which drains into a particular waterway and which is a natural topographic division of the landscape. It includes "end of catchment", where catchments join other rivers or estuaries.

Ecosystem: A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.

Estuarine: A semi-closed or periodically closed coastal body of water in which the aquatic environment is affected by the physical and chemical characteristics of both freshwater and marine systems.

Land use: Land use describes the activities that occur on land, such as agriculture, energy production, human settlements, transport, forestry, mining and conservation.

Riparian: Plant habitats and communities along the river margins and banks are called riparian vegetation.

Salinity: The accumulation of excessive salts in land and water at sufficient levels to have an impact on human and natural assets (plants, animals, aquatic ecosystems, water supplies, agriculture or infrastructure).

Turbidity: The cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air.

Sedimentation: The accumulation of sand and dirt that settles in the bottom of waterways.

Water quality: Refers to the chemical, physical, biological, and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose.

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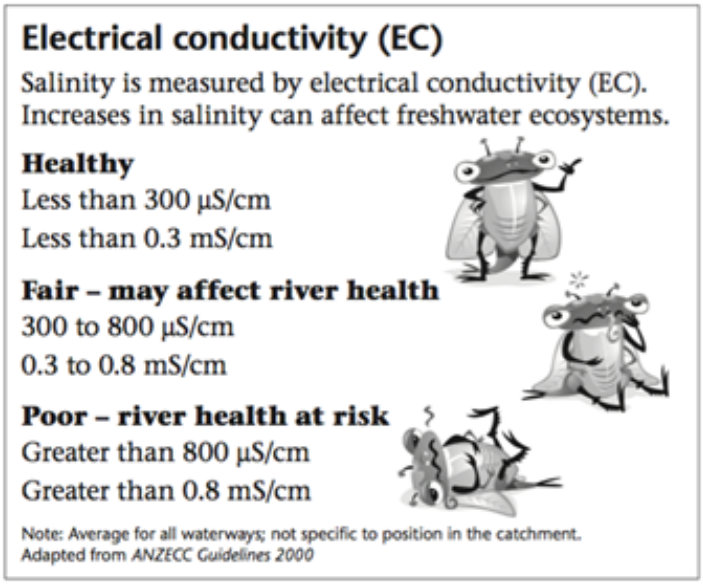
The following definitions of water quality parameters are an excerpt from the Junior Waterwatch Field Manual (Waterwatch NSW, 2016).

1. Electrical conductivity (salinity)

What is salinity?

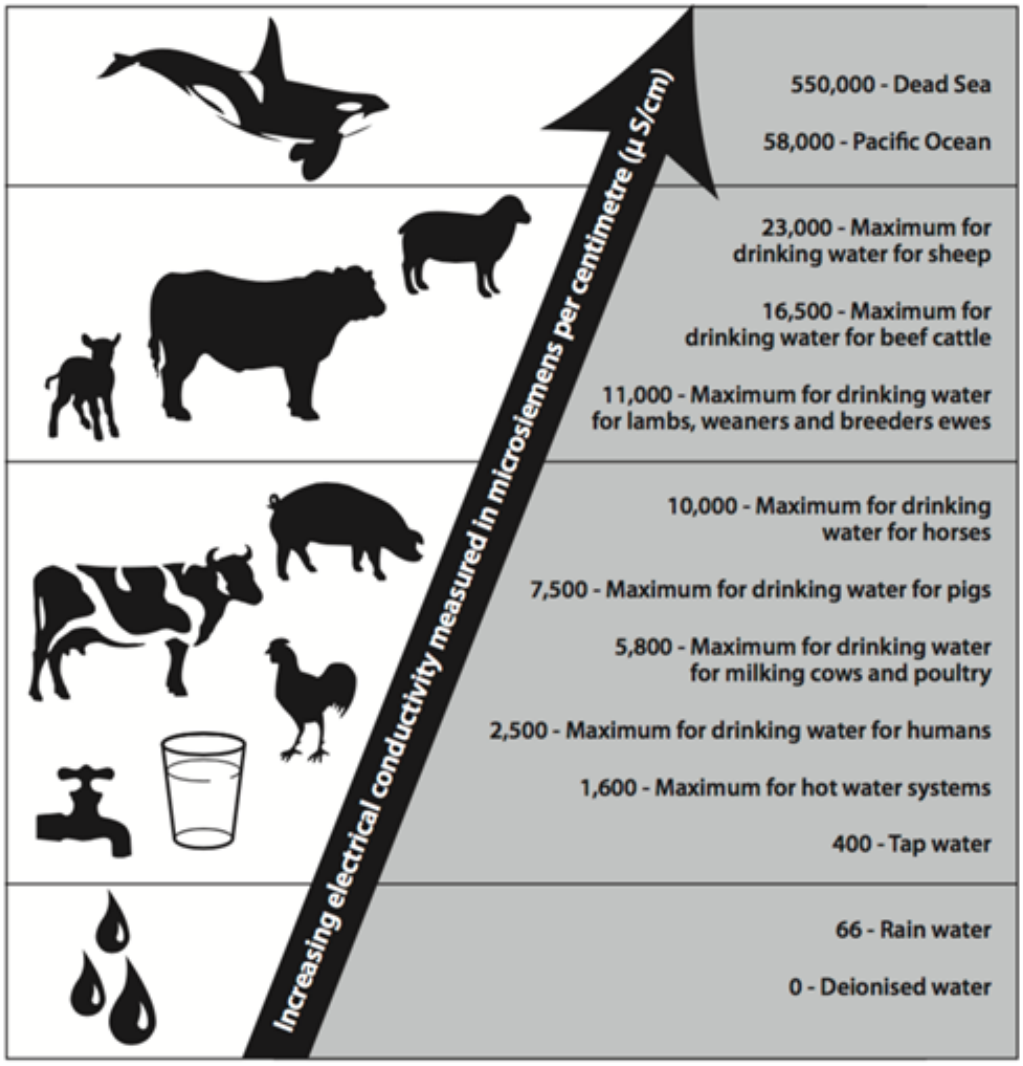
Salinity is the presence of salt in the landscape, in soil or rocks, or dissolved in water or groundwater. The most common salts include not only sodium chloride (table salt), but also the chlorides of calcium, magnesium, potassium and the bicarbonates and sulphates of these.



Why is it important?

Salt is present naturally in our land and water, but human changes due to land use have mobilised natural salt, concentrating it in certain areas of land and water, where it causes major economic and environmental problems.

Salinity is measured by electrical conductivity (EC). Salts conduct electricity, so electrical conductivity can be used to estimate the amount of salt in a water sample or soil/water solution. EC readings increase as salinity levels increase. EC is recorded in microsiemens per centimetre (µS/cm) or millisiemens per centimetre (mS/c).



Causes and consequences of increased salinity
Increases in salt in the landscape can be caused by:

- erosion of rocks containing salts
- salty groundwater storage (aquifers)
- cyclic salt – salt deposited over millions of years from the atmosphere, including salt from soil particles
- rainfall
- runoff from urban and agricultural land
- discharges from industrial areas and sewage treatment plants (STPs).

Salts can be stored in soil or water. Human activities that change the natural balance can move more salts into waterways. This can be caused by:

- removing perennial native plants (trees, shrubs and grasses)
- poor irrigation practices that use too much water
- saline groundwater seepage into creeks and rivers
- industrial and sewage effluent
- agricultural runoff
- urban development in saline areas.

Increased salinity can have a range of environmental consequences:

- salt scald, causing areas that are bare or have only salt-tolerant species
- inability to use saline waters for irrigation, drinking, industry, etc.
- dieback of trees and other vegetation
- changes to the number and diversity of living things in waterways
- damage to roads, building foundations and other infrastructure
- high water treatment costs.

2. Temperature

What is temperature?

Temperature is a measure of heat and cold. Temperature is measured in degrees Celsius (°C).

Why is it important?

The main effect of water temperature on the environment is related to oxygen in the water. The amount of oxygen that water can hold decreases as the temperature of the water increases. So if water gets too hot there is less available oxygen for living things to extract, for example, aquatic animals that need oxygen to breathe.
Temperature also affects the metabolic rate of aquatic animals, rates of development, breeding cycles, mobility, migration patterns and the sensitivity of organisms to toxins, parasites and disease. Life cycles of many organisms are related to temperature. Organisms can tolerate slow changes in temperature, but thermal stress can occur where the temperature changes more than 1 or 20C in 24 hours.

Things which affect water temperature

Temperature is directly affected by:

- depth of water
- flow rate
- season
- time of day.

Other influences on temperature include:

- air temperature
- the amount of sunlight and shade
- surrounding vegetation – provides shade and traps sediment
- turbidity – high turbidity warms the water and smothers aquatic plants
- stormwater and urban runoff from hard surfaces such as streets and footpath
- cold water releases from dams.

3. pH

What is pH?

pH is a measure of the acidity or alkalinity of a substance. The pH scale ranges from 0 to 14, where 7 is classed as neutral, 0 to less than 7 is acidic and greater than 7 to 14 is alkaline or basic. Rainwater usually has a pH value between 5.5 and 6.0. Natural sea water has a pH of 8.2. A pH range of 6.5 to 8.2 is best for most fish and other freshwater aquatic organisms.

Why is it important?

The best pH level for most organisms in Australian freshwater waterways is pH 6.5 to pH 8.2. Changes in pH outside this normal range can cause a reduction in species diversity, with many of the more sensitive species disappearing.

Things which affect pH

- Natural factors – pH will vary depending on the geology of the area. Water owing through limestone country will be alkaline but in basalt and sandstone country the water will be slightly acidic. Water from a forested catchment will be slightly acidic after draining through the leaf litter.
- Human activity – Industrial runoff and sewage may affect the pH of water. Chemicals on road surfaces \ washing into the water after rain can affect pH. The application of lime to agricultural land may raise the pH if washed into waterways, while fertilisers may lower it.
- Daily changes – pH will rise (become more alkaline) during the day due to plant photosynthesis. During the night, pH may fall.
- Chemical changes in the water – When carbon dioxide is removed from the water pH increases, and when carbon dioxide is added, pH decreases. pH can also change if polluting chemicals are added to the water.

How acidity affects waterways

Water with a pH of less than 5.5 may cause the release of heavy metals trapped in sediments. Fish and other aquatic species may suffer skin irritations, tumours, ulcers and impaired gill functioning. People may get irritated skin or eyes in affected water.

How acidity affects macro invertebrates

Water bugs have different sensitivities to low pH:

How alkalinity affects waterways
If the water is too alkaline, sh and other aquatic species may suffer skin irritations, tumours, ulcers and impaired gill functioning. People may suffer skin or eye irritations in affected water.

4. Turbidity

What is turbidity?

Turbidity is the cloudiness or muddiness of water. Particles of clay, silt, sand, algae, plankton and other substances increase turbidity.
'Blackwater' is discolouration due to natural dyes in wetland/aquatic plants or caused by leaf litter as it breaks down. Blackwater also increases turbidity.

Why is it important?
- Increased turbidity can affect:
- how much light can penetrate the water, reducing plant growth and oxygen production
- breeding and survival of sh and other aquatic animals
- water temperature, because sediments absorb more sunlight, raising the temperature
- oxygen levels, which decrease as water temperature rises
- visual clarity of water.

Causes and consequences of increased turbidity
Some waterways are naturally turbid, e.g. in clay soil areas; however, many human activities increase turbidity to unnatural levels:

- agriculture
- animals accessing waterways, particularly livestock
- removal of vegetation along stream banks
- stormwater and other urban runoff
- sewage treatment plants (STPs)
- building sites not using sediment and erosion control
- land-use changes in catchments
- industrial discharges.

When the turbidity of waterways increases beyond natural levels, the consequences may include:

- reduced light penetration leading to reduced growth of aquatic plants
- clogged fish gills
- suffocation of aquatic plants
- siltation of stream beds leading to the loss of breeding habitat
- death of water bugs or disruption to breeding cycles
- increased temperature and reduced oxygen
- reduced long-term biodiversity.

5. Rate of flow

What is rate of flow

The rate of flow is the volume of water passing a particular point in a stream at any given time. Flow rates affect water temperature, dissolved oxygen, turbidity, salinity and the concentrations of pollution levels.

Why is it important?

Stream flow will vary due to the natural variability of rainfall. However, more permanent changes have occurred due to human modi cations to the water cycle, such as the construction of dams, weirs and other channel obstructions. These obstructions even out the natural high and low flows to which many ecosystems have adapted, especially wetlands.

The best water quality usually occurs under conditions where there is sufficient flow to ensure:

- good oxygenation of the water
- dilution and flushing of pollutants
- limits to the build-up of algae.

High flows after heavy rain can also cause problems such as erosion and turbidity, especially in heavily developed areas with hard surfaces.

Consequences of changes in rates of flow
Low flow rates can lead to:

- low oxygen levels
- reduced flushing of pollutants that build up over time
- increased salinity
- larger temperature variations, placing stress on aquatic life
- increased algal growth.

High flows due to heavy rainfall or releases of water from dams can result in:

- increased sediment load
- increased turbidity
- increased nutrients
- reduced salt concentration
- increased salt loads.

Appendix 2: In class experiments to encourage student understanding of water quality impacts.

Experiment 1: CSIRO A-Salt on Salinity experiment (CSIRO, 2016)
This experiment aims to teach students the impact of salinity on plants in the environment. It involves treating individual plants with a solution of salt water in varying strengths. Students witness a gradual decrease in plant growth and plant health as the water increases in salt concentration.

Equipment you will need for the experiment:
35 wheat seeds
cling wrap
five small potting containers (polystyrene cups work well, remember to add a drain hole)
potting mix
tap water
salt
five one litre (or bigger) bottles
marking pen
results record sheet (see Appendix *). wheat seeds

Procedure:

1. Sow your seeds
a. Label each of the containers with a solution number from solution 1 to solution 5.
b. Fill each container with potting mix.
c. Place seven evenly spaced seeds into each container. Don't use the seeds that are cracked.
d. Wet the soil in each container with tap water, cover with cling film and place in a warm sunny position.
e. Grow the seedlings for about one week, until the second leaf is emerging.

2. Make your salt solutions:
a. Make the salt solutions in five clean, empty bottles.
b. Label each of your containers from solution 1 to solution 5.
c. Make your solutions according to the table below:

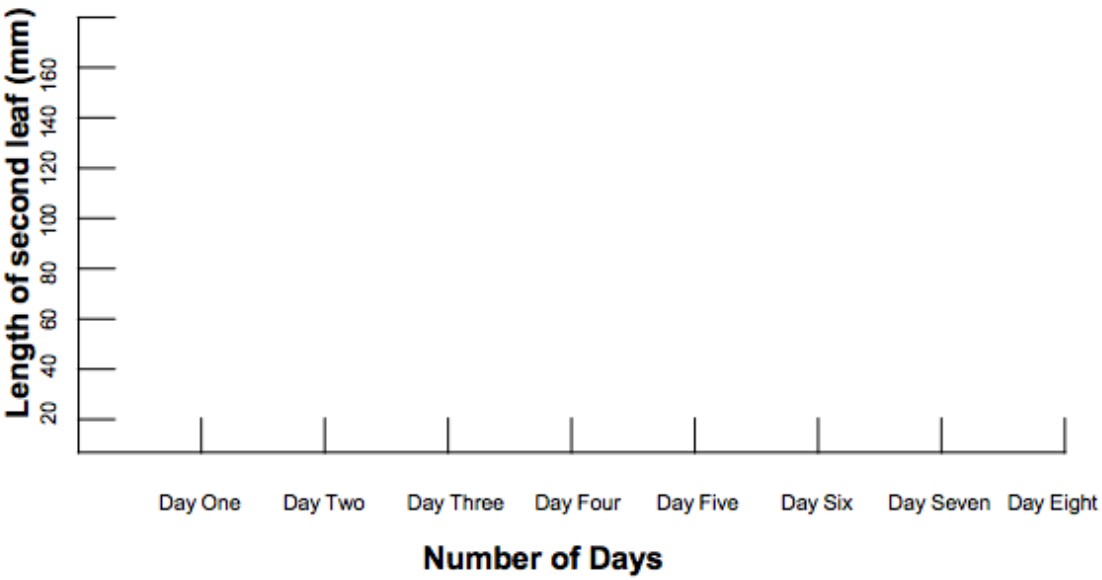
AMOUNT OF SALT IN TEASPOONS		AMOUNT OF WATER
Solution 1 (tap water)	0 (0 grams)	1 litre
Solution 2	1/2 tsp (3 grams)	1 litre
Solution 3	1 level teaspoon (6 grams)	1 litre
Solution 4	1 1/2 level teaspoons (15 grams)	1 litre
Solution 5	5 level teaspoons (30 grams)	

d. When the second leaf on each plant is about 50 millimetres long, start watering each container with the corresponding salt solution.
e. Measure and record the length of the second leaf before you put any solution on the plant, and then measure the same leaf each day after that. Use the chart below to help you record your measurements.

3. Length of second leaf in millimetres
Measure and record the length of the second leaf before you put any solution on the plant, and then measure the same leaf every day after that. Use this chart to help you record these measurements.

	day one	day two	day three	day four	day five	day six	day seven
solution 1	start watering your plant with the different solutions when the second leaf is 50 mms long. prior to this, water each plant with tap water.						
solution 2							
solution 3							
solution 4							
solution 5							

To see the results of the different solutions of salt water, make a graph that shows how fast the leaf grows in millimetres per day, and how badly the salt affects this.



Helpful hints:
- If you miss the second leaf you can use the third leaf as your test leaf. Don't use the first leaf as it only grows to approximately 100 millimetres.
- If you use table salt you will find that there is a residue that does not dissolve, it is simply the compound added to keep the salt dry.
- Plant seven seeds and pull out the worst two, which are the last two to emerge (or not emerge at all), so you are left with five good seedlings per container.

4. What's happening
In this experiment, some plants were grown with normal water. These plants should grow normally. Wheat plants grow from the base like other grasses. New cells are formed at the base of the plant and this pushes the tip along. The second leaf should grow about 30 millimetres per day, and reach a final length of about 150 millimetres. When you add salt water to the plant the growth rate of the leaves should decrease. To see the results of the different solutions of salt water, make a graph that shows how fast the leaf grows in millimetres per day, and how badly the salt affects this.
- Solution 1 should have no adverse effect on the plant and growth should be normal (30 millimetres per day)
- Solution 2 will have only a small effect on the wheat seeds
- Solution 3 should have a bigger effect
- Solution 4 will cause growth to slow dramatically and nearly stop
- Solution 5 will kill the plants.

Refer back to the healthy waterway environments that were created in Part 1 of Activity One. Have students discuss in groups the impacts that salinity would have on their healthy waterway habitats.

Experiment 2: It's sedimentary my dear Watson (Waterwatch Australia, 2016)

This experiment teaches students about the different forms of turbidity and visually explains the process of turbidity and sedimentation. It involves mixing water with different types of particles and investigating which type of particle settles the fastest.

Equipment you will need for the experiment:
For each group of students
6 plastic bottles
stopwatches
spoons
water
1/2 kg of each of the following solids for the class:
sand
gravel
dry dirt
clay soil
potting mix
salt

Procedure:

1. Fill plastic bottles with water then add a tablespoon of a different solid material to each one. Label each bottle with the corresponding material for reference. Leave them to settle overnight.
2. Look at each of the settled materials in the bottles and predict how long you think each material will take to settle after the bottle is shaken up. In pairs, students use the following table to record their data.

MATERIAL	What does the material look like?	How long do you think it will take to settle?	How long did it take to settle?
sand			
gravel			
dirt			
clay			
potting mix			
salt			

3. Prepare a stopwatch to time how long the bottles will take to settle.
4. Shake the bottles for 30 seconds with the lids secure, place the bottle straight down on a flat surface.
5. Time how long it takes for each material to settle. Make sure you start timing as soon as you have shaken the bottle. Explain to the class the difference between dispersed material (turbidity) and settled material (sedimentation).
6. As a whole class, compare the results from the table. Which material settles quickest? Why do you think it settled the quickest? Which material was slowest to settle and why?

Refer back to the healthy waterway environments that were created in Part 1 of Activity One. Have students discuss in groups the impacts that turbidity would have on their healthy waterway habitats.

Temperature

Results: Water Temp. ..... °C Air Temp. ..... °C

No set trigger value. Animals and plants in and around aquatic ecosystems are adapted to living within a particular temperature range to maintain their survival and provide reproduction cues. Taking note of 'normal' temperature conditions at this site will allow you to determine whether an increase or decrease in temperature might be harmful to this ecosystem.

Note: High water temperatures can increase algal growth in dams.

pH

Results: .....

An increase or decrease in pH may cause a loss of native plants and animals.

Tick the boxes below that relate to your result:

1	Acid	Neutral 7	Alkaline	14

My result is: ☐ Acid ☐ Neutral ☐ Alkaline

Healthy

☐ 6.5 to 8.0

Poor: plants and animals at risk

☐ <6.5 or >8.0

Salinity

Results: ..... mS/cm X 1000 = ... µS/cm

Salinity is measured by its electrical conductivity (EC).

Tick the box below that relates to your result:

Healthy

☐ Less than 300 µS/cm
Less than 0.3 mS/cm

Fair: may affect plants and animals

☐ 300–800 µS/cm
0.3–0.8 mS/cm

Poor: plants and animals at risk

☐ Greater than 800 µS/cm
Greater than 0.8 mS/cm

Turbidity

Results: ..... NTU

Increases in turbidity may cause a loss of native plants and animals.

Tick the box below that relates to your result:

Healthy

☐ Less than 15 NTU

Fair: may affect plants and animals

☐ 15 to 50 NTU

Poor: plants and animals at risk

☐ Greater than 50 NTU

Temperature

Results: Water Temp. ..... °C Air Temp. ..... °C

No set trigger value. Animals and plants in and around aquatic ecosystems are adapted to living within a particular temperature range to maintain their survival and provide reproduction cues. Taking note of 'normal' temperature conditions at this site will allow you to determine whether an increase or decrease in temperature might be harmful to this ecosystem.

Note: Cold, deoxygenated water released from dams can lack oxygen and affect plants and animals for many kilometres below the dam.

pH

Results: .....

An increase or decrease in pH may cause a loss of native plants and animals.

Tick the boxes below that relate to your result:

1	Acid	Neutral 7	Alkaline	14

My result is: ☐ Acid ☐ Neutral ☐ Alkaline

Healthy

☐ 6.5 to 8.0

Poor: plants and animals at risk

☐ <6.5 or >8.0

Salinity

Results: ..... mS/cm X 1000 = ... µS/cm

Salinity is measured by its electrical conductivity (EC).

Tick the box below that relates to your result:

Healthy

☐ Less than 350 µS/cm
Less than 0.35 mS/cm

Fair: may affect plants and animals

☐ 350–800 µS/cm
0.35–0.8 mS/cm

Poor: plants and animals at risk

☐ Greater than 800 µS/cm
Greater than 0.8 mS/cm

Turbidity

Results: ..... NTU

Increases in turbidity may cause a loss of native plants and animals.

Tick the box below that relates to your result:

Healthy

☐ Less than 10 NTU

Fair: may affect plants and animals

☐ 10 to 25 NTU

Poor: plants and animals at risk

☐ Greater than 25 NTU

Temperature

Results: Water Temp. ..... °C Air Temp. ..... °C

No set trigger value. Animals and plants in and around aquatic ecosystems are adapted to living within a particular temperature range to maintain their survival and provide reproduction cues. Taking note of 'normal' temperature conditions at this site will allow you to determine whether an increase or decrease in temperature might be harmful to this ecosystem.

Note: High water temperatures can increase algal growth in dams.

pH

Results: .....

An increase or decrease in pH may cause a loss of native plants and animals.

Tick the boxes below that relate to your result:

1	Acid	Neutral 7	Alkaline	14

My result is: ☐ Acid ☐ Neutral ☐ Alkaline

Healthy

☐ 6.5 to 8.0

Poor: plants and animals at risk

☐ <6.5 or >8.0

Salinity

Results: ..... mS/cm X 1000 = ... µS/cm

Salinity is measured by its electrical conductivity (EC).

Tick the box below that relates to your result:

Healthy

☐ Less than 300 µS/cm
Less than 0.3 mS/cm

Fair: may affect plants and animals

☐ 300–800 µS/cm
0.3–0.8 mS/cm

Poor: plants and animals at risk

☐ Greater than 800 µS/cm
Greater than 0.8 mS/cm

Turbidity

Results: ..... NTU

Increases in turbidity may cause a loss of native plants and animals.

Tick the box below that relates to your result:

Healthy

☐ Less than 10 NTU

Fair: may affect plants and animals

☐ 10 to 20 NTU

Poor: plants and animals at risk

☐ Greater than 20 NTU

Appendix 4. ANZECC Water Quality Guidelines

The following are ANZECC water quality guidelines for a range of ecosystem types, water uses (environmental values) and water quality indicators (Department of Environment, 2016 b). A water quality guideline is a recommended value or range for a given parameter. Water quality guidelines help to identify when changes in a water quality parameter have the potential to cause an environmental problem. A significant departure from a guideline may trigger further investigation and thus is called a trigger value.

Water quality stressors

Changes in water quality may put pressure on an ecosystem. They may be due to either increases or de-creases in the various water quality parameters. For example, an increase in salinity (EC or TDS) may cause stress on an ecosystem while any change in temperature may affect the same ecosystem. Such changes are called water quality stressors.

Table 1: Summary of trigger values.

	Uplands	Lowlands	Lakes	Estuaries
Temperature	-	-	-	-
pH	6.5 - 8.0	6.5 - 8.5	6.5 - 8.0	7.0 - 8.5
EC uS/ cm	350 (0.35 mS/ cm)	200 - 300 (0.2 - 0.3 mS/cm)	200 - 300 0.2 - 0.3 mS/cm)	-
Turbidity	25	50	20	10

Table 2: ANZECC default trigger values for nutrients, pH and dissolved oxygen.

Ecosystem Type	TP (ug/L)	FRP-P (ug/L)	TN (ug/L)	NOx-N (ug/L)	NH_4^+ - N (ug/L)	pH *	DO (%sat)
Lowland River	50	20	500	190	20	6.5 - 8.0	85 - 110
Upland River	13	5	480	190	135	6.5 - 7.5	90 - 110
Lakes and Reservoirs	10	5	350	10	10	6.5 - 8.0	90 - 110

Table 3: NZECC default low-risk trigger values for salinity (measured as conductivity).

Ecosystem type	Conductivity (mS/cm)	Explanatory notes
Lowland Rivers	125-2200	Lowland rivers may have higher conductivity during low flow periods with saline surface water and groundwater inputs. Low values are found in eastern highlands of Victoria (125 mScm-1) and higher values in western lowlands and northern plains of Victoria (2200 mScm-1). NSW coastal rivers are typically in the range 200 - 300 mScm-1.
Upland Rivers	30-350	Conductivity in upland streams will vary depending upon catchment geology. Low values found in Vic alpine regions (30 mScm-1) and eastern highlands (55 mScm-1), high value (350 mScm-1) in NSW rivers. Tasmanian rivers mid-range (90 mScm-1).
Lakes/ Reservoirs	20-30	Conductivity in lakes and reservoirs are generally low, but will vary depending upon catchment geology. Values provided are typical of Tasmanian lakes and reservoirs.

Table 4: ANZECC default low-risk trigger values for turbidity.

Ecosystem type	Turbidity (NTU)	Explanatory notes
Lowland Rivers	6-50	Turbidity in lowland rivers can be extremely variable. Values at the low end of the range would be round in rivers flowing through well-vegetated catchments and at low flows. Values at the high end of the range would be found in rivers draining slightly disturbed catchments and in many rivers at high flows.
Upland Rivers	2-25	Most good condition upland streams have low turbidity. High values may be observed during high flow events.
Lakes & Reservoirs	1-20	Most deep lakes and reservoirs have low turbidity. However shallow lakes and reservoirs may have higher natural turbidity due to wind-induced resuspension of sediments. Lakes and reservoirs in catchment with highly dispersable soils will have high turbidity.

Appendix 5: Sampling and Measuring Water Quality Parameters Procedures

Collecting a surface water sample

1. Use an extension pole (long arm sampler) so that the water sample is collected away from the edge of the bank.
2. Rinse the collection bottle three times with water from downstream of the test site, i.e with water from the same area. Empty rinse water onto the bank or away from the water source to avoid stirring up the water you are about to test.
3. Extend the pole with the sample bottle in place. Make sure the pole is not too long and difficult to handle.
4. Turn the bottle top down over the water and submerge it about 20cm or to elbow depth if possible. In shallow water make sure you do not disturb the stream bed as this may discharge sediments that will contaminate your sample.
5. Once the bottle is under water, turn it sideways, pointing upstream (into the direction of flow) and allow it to fill.
6. Turn the bottle upright and quickly bring it up out of the water to avoid surface scum contaminating the sample.
7. Use the same sample for all tests conducted at the site.

Measuring temperature

Temperature is a measure of heat and cold in degrees Celsius.

Air temperature

1. Measure the temperature in the shade, wait for one minute before reading the thermometer.
2. Record your results.

Water temperature

1. Lower the thermometer into the water (in the creek or in a freshly collected sample).
2. Keep the thermometer in the water for one minute before taking the temperature reading. Read the thermometer while it is still in the water.
3. Repeat the test with a different student reading the thermometer to verify the results.
4. Record your results.

Measuring pH

pH is a measure of acidity and alkalinity measured on a scale of 0 - 14

1. Shake the sample of water.
2. Take a pH strip and dip all the coloured squares into the sample water.
3. Leave the strip in the water for five minutes.
4. Remove the strip and match its colours against the colour chart to work out your pH. If you cannot match the colours exactly you can estimate between two colours to 0.5 of a pH unit.
5. Record your results.

Measuring total dissolved solids/ electrical conductivity

Total dissolved solids (TDS) is a measure of salinity. The TDS meter measures electrical conductivity and converts this measurement to an amount of salt in parts per million (ppm) or milligrams per litre (mg/L). Electrical conductivity is the amount of transfer of electricity through water.

1. Testing for either total dissolved solids or electrical conductivity will be carried out by your South Coast Natural Resource Management Officer.
2. Record your results.

Measuring turbidity

Turbidity measures the muddiness or cloudiness of the water.

1. Testing for turbidity will be carried out by your South Coast Natural Resource Management Officer.
2. Record your results.

Measuring rate of flow

The rate of flow is the speed or velocity of water movement.

1. Measure out 20 metres along the top of the water bank (two natural markers such as trees can be used).
2. From the upstream marker, throw a stick into the water and start the stopwatch.
3. When the stick reaches the second marker, stop the stopwatch.
4. Divide the distance by the time taken to calculate flow.
5. Record your result.

Preserving samples

If you cannot do all the tests when the water sample is taken, some can be done later if samples are properly preserved. This is particularly useful if a Natural Resource Management Officer is unable to attend the excursion with you.

Follow these guidelines for preserving samples:

PARAMETER	PRESERVATION METHOD	MAXIMUM HOLDING TIME
pH	refrigeration	6 hours
Conductivity	refrigeration	30 days
Turbidity	none required	24 hours

MACROINVERTEBRATES

1. OVERVIEW

Students with identify and classify different aquatic macro invertebrates found in a wetland system and understand the importance of water quality.

2. LINKS TO AUSTRALIAN CURRICULUM

STRAND	SUB-STRAND / KEY ORGANISING IDEAS
SCIENCE Science as a human endeavour	Nature and development of science Use and influence of science
Science inquiry skills	Communicating Evaluating Planning and conducting Processing and analysing data and information
Science understanding	Biological sciences Earth and space sciences

3. OBJECTIVES

Students will:

- Identify types of macroinvertebrates and their role in the food web.
- Understand the importance of water quality in supporting macroinvertebrate communities.
- Draw conclusions about the health of waterways and the impacts on macro invertebrates and other living things connected to the wetlands.

TOPICS
Macroinvertebrates
Waterway health
Invertebrate communities

PHASES OF LEARNING
3-6, 7-9

SITE (LOCATION)
Classroom
Local wetland

ACTIVITIES
1.1 In class (1.5 hrs)
1.2 In class (1.5 hrs)
2.1 Wetland (1.5 hrs)
2.2 In class (1.5 hrs)

MATERIALS
- Copies of the "whose body is this" series of macroinvertebrates
- Copies of the "mix and match" series of macroinvertebrates students.
- Plastic sandwich bags/ paper envelopes.
- Blu-tac or sticky tape.
- Plastic lunch bags
- M&Ms, smarties, skittles or coloured counters
- Textas/ coloured pencils/ crayons
- Glue
- Copy of the "Field guide to Aquatic Macroinvertebrates of the South Coast of Western Australia"
- Fine mesh nets for sampling macroinvertebrates
- Large white sorting trays
- Ice block trays
- Pipettes, plastic spoons, paint brushes and tea strainers
- Magnifying glasses
- Student worksheets to record information
- Clipboard
- Sturdy shoes, water bottles, protective clothing
- Macroinvertebrates sampling procedures

STUDENT WORKSHEET
Macroinvertebrates in our environment recording graph
Water bug survey worksheet
Calculating the health of your site worksheet

4. TEACHER BACKGROUND INFORMATION

4.1 What are macroinvertebrates?

Aquatic macroinvertebrates are small animals without a backbone that live for all, or part, of their lives in water. There are many different types of macro invertebrates such as dragonfly larvae, mosquito larvae, water fleas, beetles and snails (Department of Water, 2016 a). Some macroinvertebrates can be large, like the freshwater crayfish, while others, such as aquatic mites, copepods and water fleas are much smaller and harder to see (South Coast NRM, 2016).

Depending on the species, they live in different parts of the waterway such as the water surface, waterway floor, shoreline or amongst aquatic vegetation (Melbourne Water, 2016). Although they can be very small, macroinvertebrates are an important group of animals. Some shred plant matter into smaller pieces which filter feeders and detritivores collect, while others graze on algae growing on the sand and rocks. Then there are the predators which feed on the shredders and grazers. These macroinvertebrates then provide food for larger animals like birds, crayfish, fish and turtles that also live in waterways (South Coast NRM, 2016).

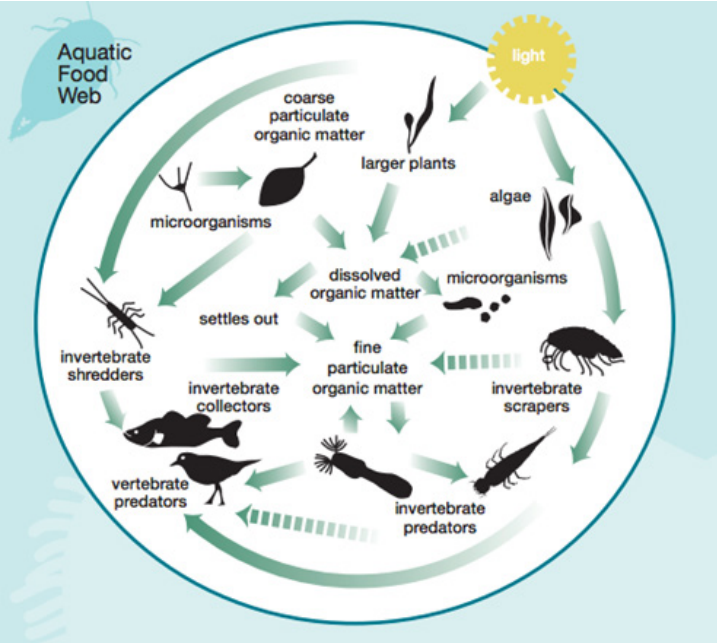


Figure 1: The aquatic food web (South Coast NRM, 2016).

Aquatic macroinvertebrates can be grouped according to their species. There are six major groups, these include insects, spiders and mites, crustacea, molluscs, segmented worms and unsegmented worms. Macro invertebrates can be identified by whether they have legs, and how many pairs, whether they have a shell, or whether they have neither of these distinguishing features (South Coast NRM, 2016). Most macroinvertebrates have three body segments; the head, thorax and abdomen. The head section contains the head and antennae. The midsection of the body is called the thorax. It bears the jointed legs and wings (in the case of insects). The lower section of the body is the abdomen.

All aquatic macro invertebrates start life as eggs. Some macro invertebrates, such as the diving beetle (Coleoptera) and water boatmen (Hemiptera), do not change much as they grow – they get bigger but look basically the same. Some macroinvertebrates change (metamorphose) quite dramatically as they grow. After hatching, the insect may go through several stages before reaching adulthood. Depending on the species, it may go through a larval stage, a nymph stage, or both (Melbourne Water, 2016). Many of the macroinvertebrates you see in rivers and wetlands are in larval stages of flies, mosquitoes and dragonflies, which live outside of the aquatic environment once they reach adulthood. The other types you might see are young forms of macro invertebrates that spend their entire life in the water and look like a smaller version of the adult form (South Coast NRM, 2016).

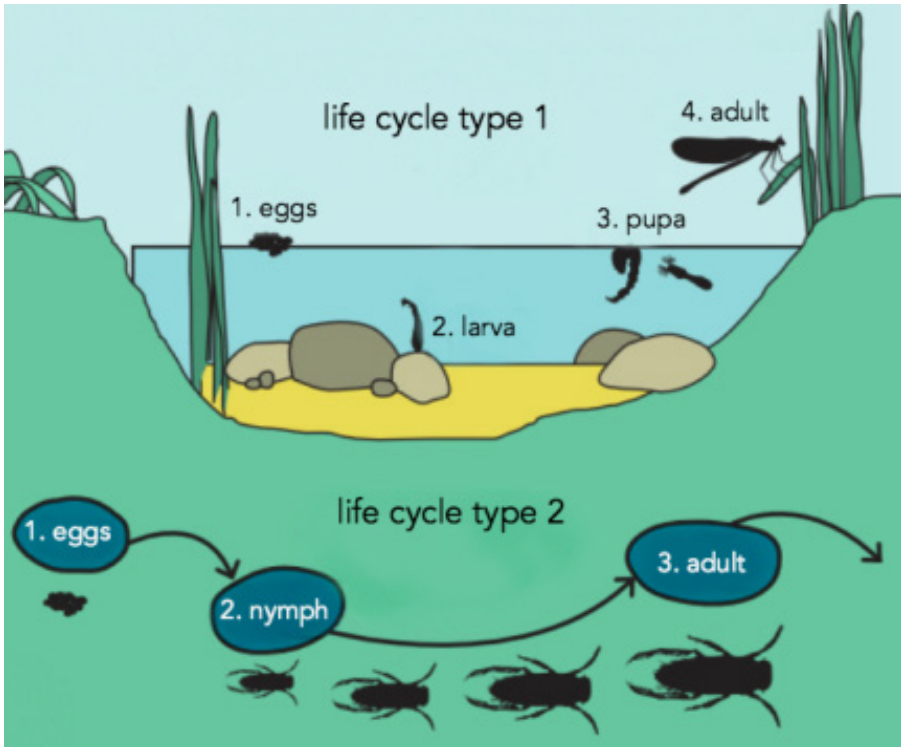


Figure 2: Life cycle of macroinvertebrates (South Coast NRM, 2016).

Sampling water quality on its own to assess the health of a waterway gives us a good idea as to what contaminants are present at the time of sampling. What it does not tell us is whether these contaminants are having an impact on the environment and, if so, to what extent (Department of Water, 2016 a). Some macroinvertebrates are sensitive to pollution whereas others can live in very polluted waters. Because of this variability in sensitivity to pollution, macro invertebrates make good biological indicators (South Coast NRM, 2016). By sampling macro invertebrate communities and looking at both the types and numbers of animals present we can get an idea as to how healthy a waterway is. Examining the macroinvertebrate communities can give us a much better understanding of the overall impacts that any contaminants present are having on the environment (Department of Water, 2016 a).

A healthy waterway will have a large number of different types of macroinvertebrates present with no one type dominating the system. A polluted waterway will have only a few different types of macro invertebrates present, often in large numbers and generally include things like aquatic worms, water fleas and non-biting midge larvae (Department of Water, 2016 a). Stoneflies, mayflies and caddisflies are not well adapted to living in water with high levels of pollution, and for this reason they are called “indicator species”.

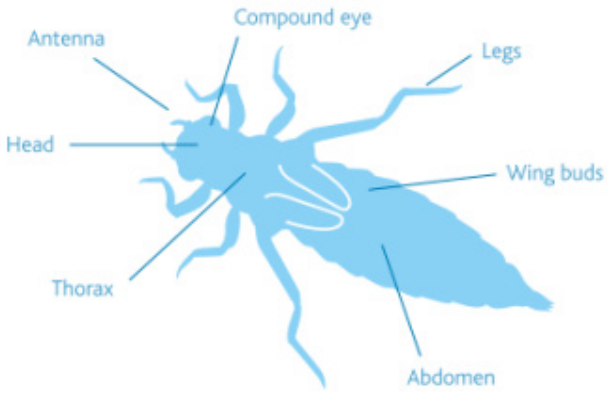


Figure 3: Characteristics of an adult insect (Melbourne Water, 2016)

4.2 Macroinvertebrates in Australia and the Esperance Region

Macroinvertebrate communities vary across Australia and different waterbodies often have their own characteristic communities. As many of the waterbodies in Western Australia are not permanent, animals are tolerant to a wide variety of environmental conditions. Most have a phase within their life cycle to escape extreme conditions (Water and Rivers Commission, 2001).

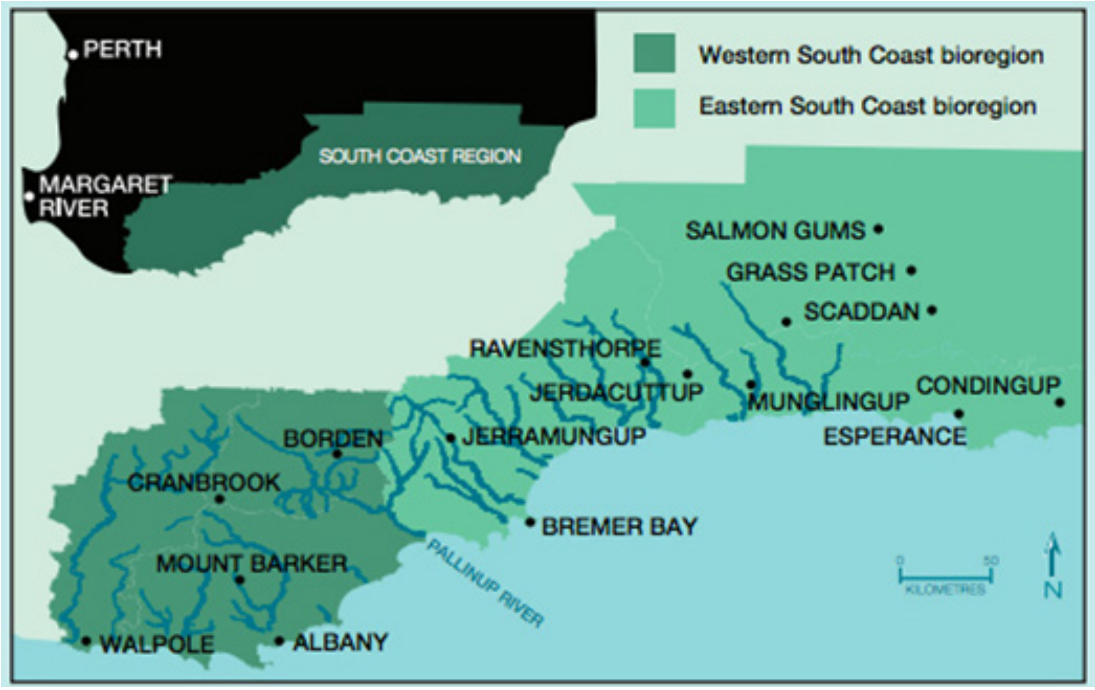


Figure 4: Bioregions of the South Coast (South Coast NRM, 2016).

The South Coast Region's waterways are home to a number of endemic species found only in southern WA, including rare species that have narrow distribution ranges. Special macroinvertebrate fauna include amphipods, freshwater crayfish, mayflies, stoneflies, caddis flies, dragonflies, freshwater mussels and fresh water limpets (South Coast NRM, 2011). A study into the ecological values of waterways in South Coast Region was undertaken in 2008 and macro invertebrate species richness for the Eastern South Coast Bioregion ranged from 15 - 79 species (Cook et al, 2008).

4.3 Threats to macro invertebrates in the Esperance Region

The quality of water in river systems and wetlands across the Esperance Region has a direct impact on aquatic plants and animals. Catchment clearing and altered land use resulting in changed hydrology and increased salinity levels are major threats to macro invertebrate communities. These land use threats can also be associated with increased erosion, sediment transportation, and altered turbidity and nutrient levels (South Coast NRM, 2011).

In highly turbid water the light penetration is reduced, affecting photosynthesis of plants. Turbidity can also increase the temperature of water, affecting sensitive macroinvertebrate communities (Department of Water, 2016 a). Suspended solids can clog respiratory surfaces or interfere with feeding appendages (Water and Rivers Commission, 2001). High levels of suspended solids in a waterway settle and change the composition of the bed as it coats rocks and vegetation. This can affect movement, feeding, habitat and reproduction of some macroinvertebrates (Water and Rivers Commission, 2001).

The riparian vegetation zone balances the temperature in an aquatic ecosystem. Large proportions of riparian vegetation has been cleared from waterways in the Esperance Region and this gives rise to more light penetration and an increase in turbidity from exposed soil (South Coast NRM, 2011). High levels of nutrients from nitrogen and phosphorus based fertilisers can activate excessive algal growth (algal blooms). The death and decay of these algae can produce toxins and stagnant conditions. In these conditions, macro invertebrate community diversity is usually reduced but there is generally an increase in the abundance of a few species. These macroinvertebrates are able to take advantage of the altered conditions and exploit the excess of food supply. Red midge larvae (Chironomids) are very tolerant to low levels of dissolved oxygen (Water and Rivers Commission, 2001).

5. ACTIVITIES

5.1 ACTIVITY ONE: Understanding macro invertebrates

Overview:

This activity has two parts. In this activity, students will be introduced to macro invertebrate species in the Esperance Region. Students will learn how to identify the major segments (head, thorax and abdomen) and the differences between larval, lymph and adult stages. Students will also learn about the impacts of land use, catchment health and the link between macro invertebrates and water quality decline.

PART ONE: Macroinvertebrate mix and match
In class activity. Allow 1.5 hours.

Required Resources

- One printed copy of the "whose body is this" series of macroinvertebrates per group of 3 - 4 students, for the activity of matching body parts. Keep several copies of the macroinvertebrate series for a whole class activity, and for the student copies cut each one into three sections - the head, thorax and abdomen. Place the cut out pieces into an envelope or plastic bag, one set of macroinvertebrates for each group of students.
- One printed copy of the "mix and match" series of macroinvertebrates per group of 3 - 4 students for the activity of matching larval/ nymph invertebrates with their adult version. Place the images into an envelope or plastic bag, one set of macro invertebrates for each group of students.
- Drawings that were completed as part of Activity 1 - What is a waterway, from the Water Quality lesson plan.
- Plastic sandwich bags/ paper envelopes.
- Blu-tac or sticky tape.

Teacher Preparation:

- Read Teacher Background Information in Macroinvertebrates lesson plan.
- Familiarise yourself with the "Field guide to Aquatic Macroinvertebrates of the South Coast of Western Australia" (South Coast NRM, 2016), a detailed manual for sampling and identifying macroinvertebrates on the South Coast. A full copy of this field guide will be required, the link to download and print is in the reference section.
- Familiarise yourself with "A Beginners Guide to Waterbug Identification (Melbourne Water, 2016), a guide for identifying freshwater animals to aid in surveys and observational data collecting. The link to download is in the reference section. Print out the pages for amphipods, copepods, damselflies, adult diving beetles, dragonflies, freshwater shrimps, springtails, stoneflies, water measurers and water scorpions. These contain detailed information about the macroinvertebrate species used in the "mix and match" activity.
- Print and cut out the macro invertebrate images from Appendix 1. These will be used for the classroom activities "whose body is this" and "mix and match", and for sticking onto the healthy waterway environments drawn as part of the Water Quality education program.

- Revisit Water Quality Testing lesson plan, specifically Activity One: Understanding water quality and habitat. Pin up these drawings in the classroom so that they are accessible to students.

Procedure:

1. Using excerpts from the "Field Guide to Aquatic Macroinvertebrates of the South Coast Region of Western Australia" and the series of macro invertebrate information cards (Appendix 1), introduce the class to macro invertebrate species found in the Esperance Region. Discuss the different types of macro invertebrate species (insects, spiders and mites, crustacea, molluscs, segmented worms and unsegmented worms) and the role they play in an aquatic ecosystem. Pages 10 and 11 of the field guide contain very good illustrations for showing macroinvertebrate diversity in the South Coast Region, size differences and body parts.

2. Divide students into small groups and assign each group a healthy waterway environment drawing that was completed in Activity 1 of the Water Quality Testing education program. Each group will discuss the different types of macro invertebrates and where they think each invertebrate would live in the waterway environment (on top of the water, in the body of water, on the bottom of the waterway, in vegetation on the bank of the waterway). Have students stick the macroinvertebrates to the waterway habitat and share back with the class.

3. There are two components to the "mix and match" learning activity (students may need some guidance with these activities, depending on their level of understanding):

- In the first component, small groups of students are given cut outs of different macroinvertebrate species and they need to match the three body segments for each (the head, thorax and abdomen).
- In the second component, small groups of students are given pictures of macro invertebrates in different stages of growth. Students need to try and match the larval/ lymph stage with the adult macroinvertebrate.

PART TWO: Macroinvertebrates in our environment
In class activity. Allow 1.5 hours.

Overview:

In this activity, students will evaluate the quality of a "water sample" (using a bag of M&Ms, skittles or smarties to represent pollution and pictures of aquatic macroinvertebrates to represent invertebrates found in their sample). They will graph their results and form a hypothesis about the catchment management and land uses for the waterway their sample was taken from.

Required Resources:

- One printed copy of the macroinvertebrates per group of 3 - 4 students
- Two printed graphs per group of students
- Key ideas from Activity 2 - discussion of water quality results
- Plastic lunch bags
- M&Ms, smarties, skittles or coloured counters
- Textas/ coloured pencils/ crayons
- Glue

Teacher Preparation:

- Read Teacher Background Information in Invertebrates Lesson Plan.
- Revisit Activity Two - how does water quality affect habitat, from the Water Quality Testing lesson plan. Pin up around the classroom some key ideas about management actions to reduce threats to water quality.

- Print and cut out the macroinvertebrate images contained in Appendix 2.
- Print out the "macroinvertebrates in our environment" graph contained in Appendix 3.
- Assemble the "water samples" with your choice of coloured lollies. You can use coloured counters if you prefer. For each group of students, make one water sample with good/ medium water quality, and one sample with poor water quality. Use the following colours for your water quality parameters (or change them depending on the lollies/ counters you use for the activity).

  Blue = water
  Red & orange = salinity
  Green = nutrients
  Yellow = sediment

  Not all water samples need to be the same across the class, just so long as each group of students has one sample with either good or medium water quality and one sample with poor water quality. The activity uses macroinvertebrates with a range of pollution tolerances from high, medium and low.
- Place the corresponding macro invertebrates into each water sample, using the table below. Not all the macro invertebrates need to be used for each group.

Species with high sensitivity to pollution	Species with medium sensitivity to pollution	Species with low sensitivity to pollution
mayfly	blackfly	back swimmer
stonefly	damselfly	diving beetle
caddisfly	dragonfly	water boatman
	flat worm	water strider

As an example, three different water samples can be made up using the following number of different coloured M&Ms:

- good water quality sample containing 20 blue, 5 red & orange, 2 green and 3 yellow M&Ms and the stonefly, mayfly and caddisfly macro invertebrate larva.
- medium water quality sample containing 15 blue, 5 red & orange, 5 green and 5 yellow M&Ms and the black fly, dragonfly and damselfly macro invertebrate larva and flat worm.
- poor water quality sample containing 5 blue, 10 red & orange, 5 green and 15 yellow M&Ms and the back swimmer, water boatman, diving beetle and water strider macroinvertebrates.

Procedure:

1. Divide students into groups and hand out the water samples and graphs.
2. Explain to the class you have taken water quality samples from several waterways in the Esperance Region. Describe the different water quality parameters within each bag (water, salinity, nutrients and sediment) and the macro invertebrates with differing levels of sensitivities to water quality decline.
3. Have the groups of students count the number of each parameter found in their water samples, make sure the samples are kept separate from each other (remind students they can't eat the lollies until they have been counted!). Each group will colour a bar graph to illustrate the level of water quality parameters found in their water samples. Glue onto each graph the macroinvertebrates that were living in the water sample.
4. In small groups, students will discuss why they think the macro invertebrates are different in each water sample. Encourage students to think about the catchment uses or land use threats that may cause higher levels of salinity, nutrients and sediment in their samples.
5. Revisit Activity Two - understanding water quality and habitat, from the Water Quality Testing lesson plan. Discuss as a class the importance of catchment health, water quality and land use in protecting macro invertebrate species.

5.2 ACTIVITY TWO: Macroinvertebrate sampling and analysis

Overview:

This activity has two parts. In this activity, students will observe the plants, animals and environment of a significant waterway in the Esperance Region. Students will undertake sampling of macro invertebrate species and identify broad groups of macro invertebrates using a "dichotomous key". Students will then discus the results of the sampling and relate to waterway health.

PART ONE: Macroinvertebrate sampling
In field activity. Allow 2-3 hours (incorporate travel time)

Required Resources:

- Copy of the "Field guide to Aquatic Macro Invertebrates of the South Coast of Western Australia"
- Fine mesh nets for sampling macroinvertebrates
- Large white sorting trays
- Ice block trays
- Pipettes, plastic spoons, paint brushes and tea strainers
- Magnifying glasses
- Student worksheets to record information
- Clipboard
- Sturdy shoes, water bottles, protective clothing
- "Macroinvertebrates sampling procedures" (Appendix 6) for easy access in the field.

Teacher Preparation:

- Decide on a waterway in the Esperance Region that you would like to investigate with your class. You may choose the same waterway you tested for water quality, or a waterway from a different catchment.
- Revisit the different types of macroinvertebrate species and their characteristics. Background information is provided in Section 4 of this lesson plan and the "Field guide to Aquatic Macroinvertebrates of the South Coast of Western Australia" (South Coast NRM, 2016), a detailed manual for sampling and identifying macro invertebrates on the South Coast.
- Print out and laminate a full copy of the "Field guide to Aquatic Macroinvertebrates of the South Coast of Western Australia". You will be using the guide to undertake sampling and identification at your waterway. The link to download and print is in the reference section.
- Laminate copies of "Macroinvertebrates sampling procedures" (Appendix 6) for easy access in the field.
- For additional information about sampling and identifying macro invertebrates, see the "Western Australia AUSRRIVAS sampling and processing manual (Department of Water, 2016 b) and the "Monitoring River Health Initiative Technical Report: SIGNAL - A Scoring System for Macroinvertebrates in Australian Rivers" (Department of Environment, 2016). The link to download and print full copies of this manual and technical report is in the reference section.
- Print out the student work sheets from Appendix 4 that are used to record details of your chosen waterway.

Procedure:

1. Visit your chosen waterway with a South Coast Natural Resource Management Officer to assist with the macroinvertebrate sampling and identification.
2. Go for a walk around the waterway, observe with the class the physical landmarks, plants, animals and any other distinguishing features. Have each student draw a location map of your waterway.
3. Undertake macro invertebrate sampling in groups and record your findings on the student worksheet. The following procedural guidelines which have been adapted from the Junior Waterwatch Field Manual

(Waterwatch NSW, 2016), see Appendix 6.
Note: Edge sampling is recommended for school students due to the OH&S issues relating to students entering creeks, rivers and wetlands.

PART TWO: Discussion of macroinvertebrate results
In class activity. Allow 1.5 hours.

Required Resources:

- Student worksheets for calculating the health of your site
- Completed macro invertebrate worksheets

Teacher Preparation:

- Familiarise yourself with the worksheet in Appendix 5 for calculating the health of your site.
- Revisit the information in Appendix 1 of the Water Quality education program about the causes of water quality decline and threats to habitat in the Esperance Region.

Procedure:

1. Interpret with your class the results of the macroinvertebrate sampling and the health indication of your waterway.
2. Revisit Activity Two - macroinvertebrates in the environment. Discuss further as a class the importance of catchment health, water quality and land use in protecting macro invertebrate species.

VOCABULARY

Catchment: The land area which drains into a particular waterway and which is a natural topographic division of the landscape. It includes "end of catchment", where catchments join other rivers or estuaries.

Dichotomous key: A dichotomous key is a tool that allows the user to determine the identity of items in the natural world, such as trees, wildflowers, mammals, reptiles, rocks, and fish.

Ecosystem: A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.

Estuarine: A semi-closed or periodically closed coastal body of water in which the aquatic environment is affected by the physical and chemical characteristics of both freshwater and marine systems.

Land use: Land use describes the activities that occur on land, such as agriculture, energy production, human settlements, transport, forestry, mining and conservation.

Macro:The term used for invertebrate fauna that can be captured by a Invertebrates: 500--µm net or sieve. This includes arthropods (insects, mites, scuds and crayfish), molluscs (snails, limpets, mussels and clams), annelids (segmented worms), nematodes (roundworms), and platyhelminthes (flatworms).

Riparian: Plant habitats and communities along the river margins and banks are called riparian vegetation.

Salinity: The accumulation of excessive salts in land and water at sufficient levels to have an impact on human and natural assets (plants, animals, aquatic ecosystems, water supplies, agriculture or infrastructure).

Turbidity: Is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air.

Sedimentation: The accumulation of sand and dirt that settles in the bottom of waterways.

Water quality: Refers to the chemical, physical, biological, and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose.

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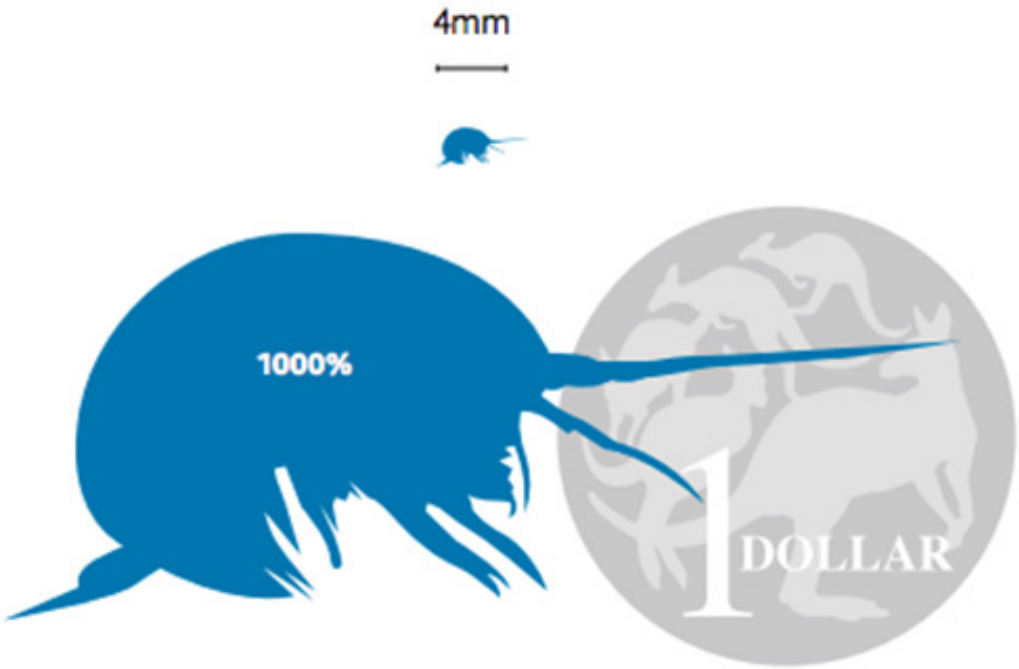
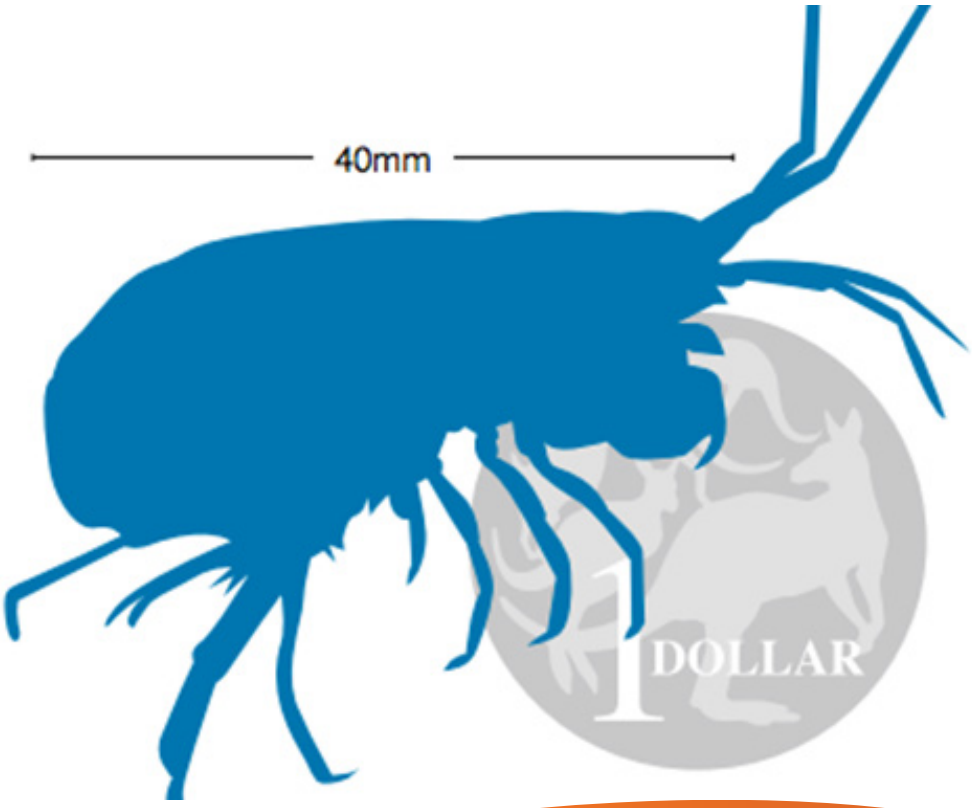
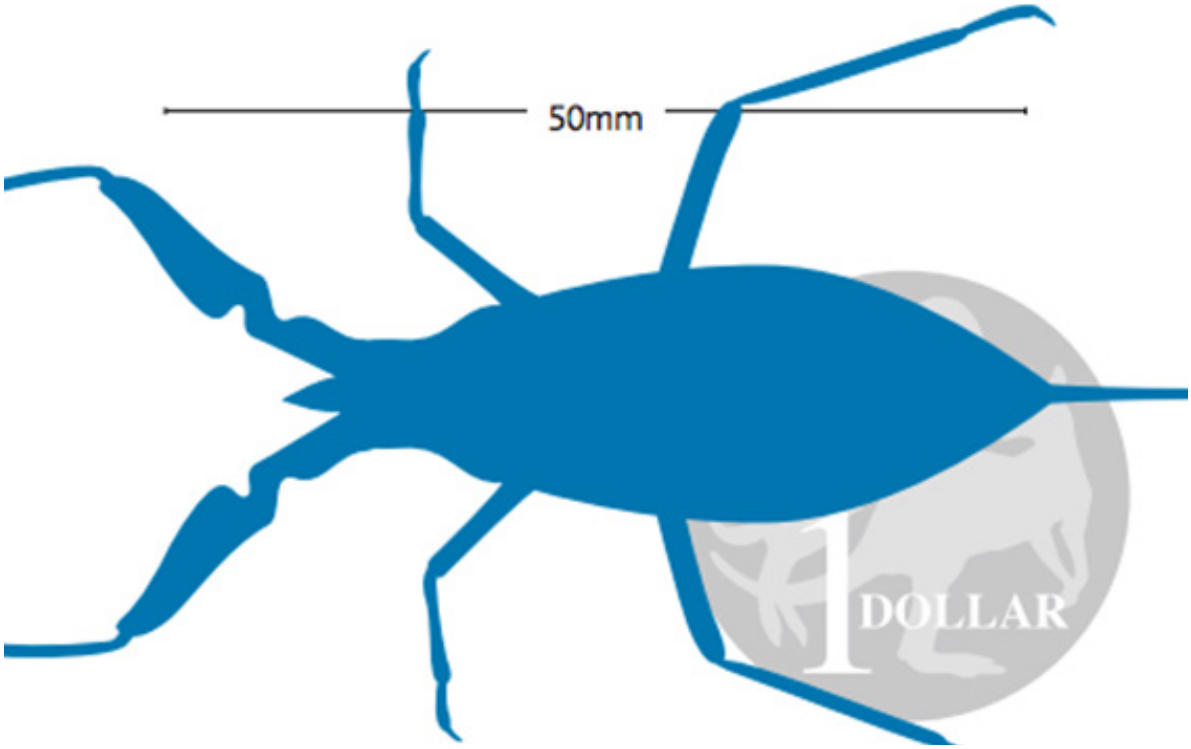
Copepod



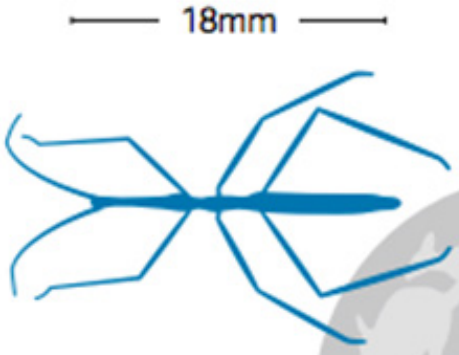
Freshwater shrimp



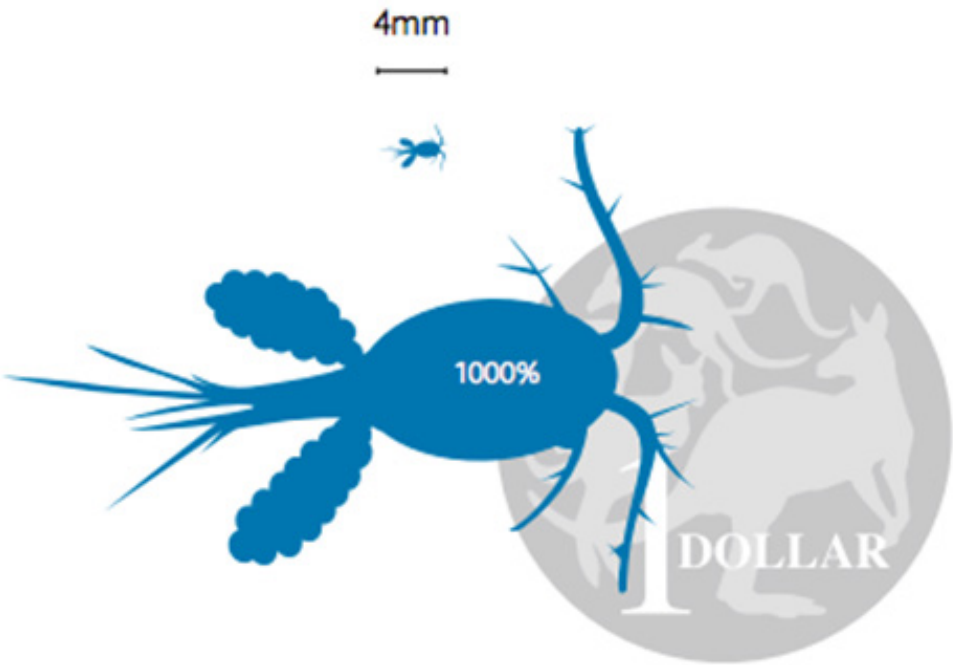
Water scorpion



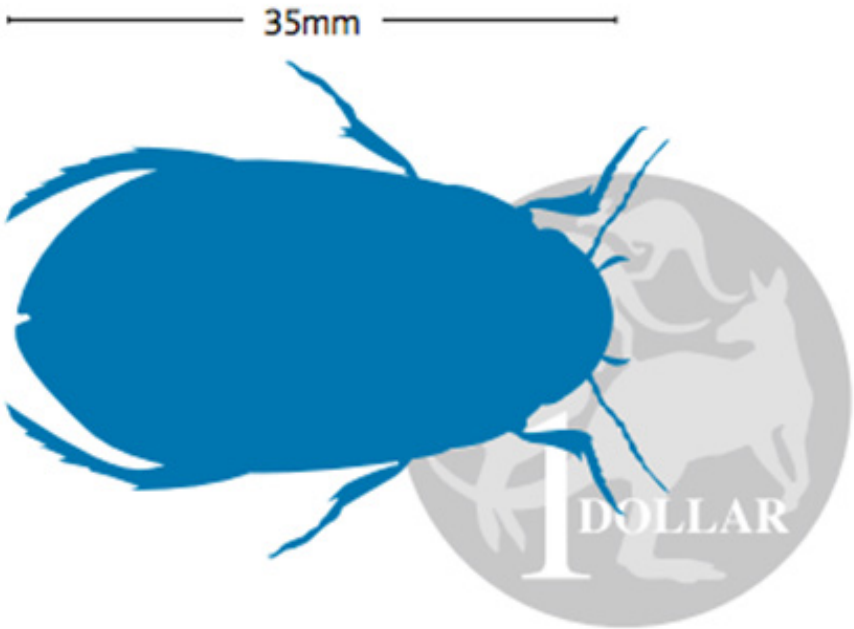
Water measurer



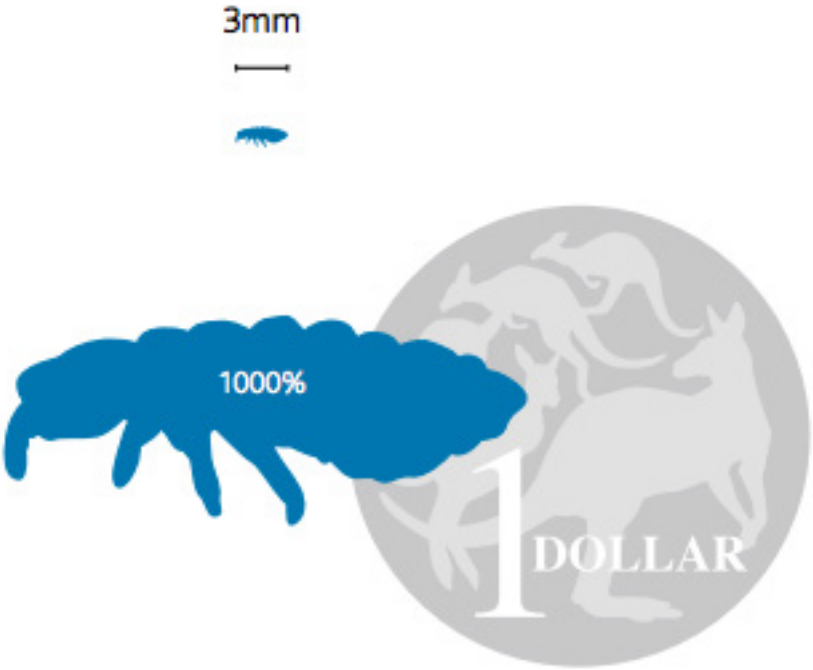
Copepod



Diving beetle



Springtail

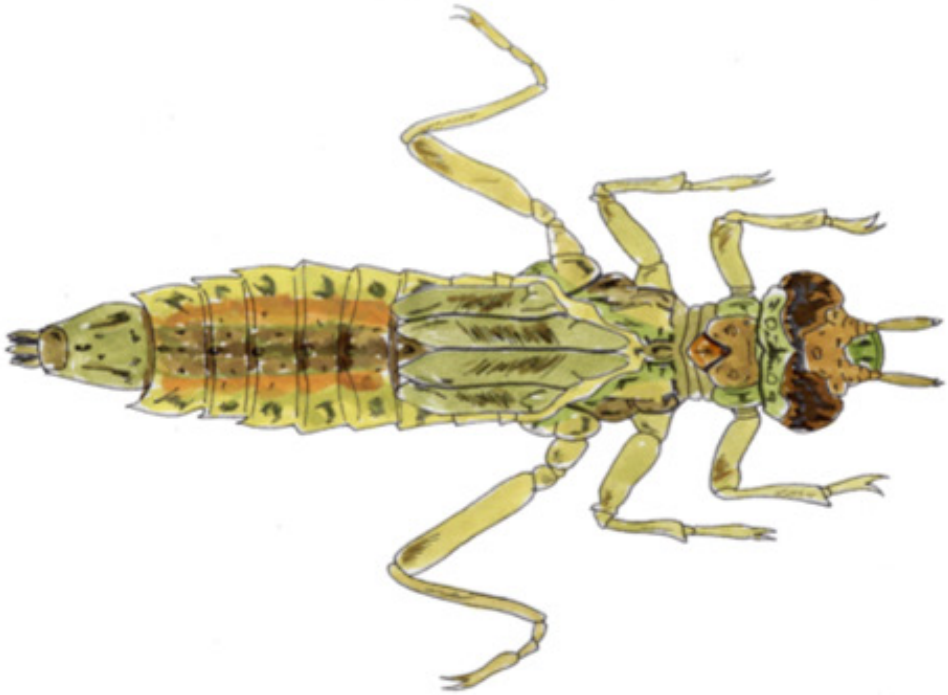


Blackfly

Caddisfly

Cranefly

Dragonfly



Appendix 2:

Macro invertebrates with high pollution tolerance

Diving Beetle

Rat-Tailed Maggot

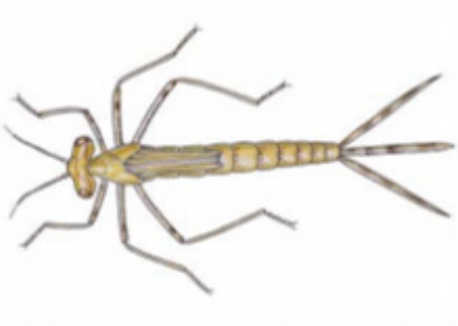
Water boatman

Back swimmer

Water Strider

Macro invertebrates with medium pollution tolerance

Cranefly



Damselfly

Blackfly

Dragonfly

Flat worm

Caddisfly

Stonefly

Stonefly

Mayfly

Mayfly

Appendix 3: Macroinvertebrates in our environment recording graph

water		salinity		nutrients		sediment

Water bug survey: SIGNAL 2 result sheet

Survey site name: .....

Step 1: Tick the bug type if present.
Step 2. Enter the number of each bug found in Column B.
Step 3: Refer to the weight table for the correct weight factor for the number found.
Step 4: Enter the correct weight factor for each bug in Column C.
Step 5: Multiply the bug value (Column A) by the weight factor (Column C) and enter the answer in Column D.
Step 6: Add up Column C (weight factors).
Step 7: Add up Column D (bug value x weight factor).
Step 8: Add up the number of bug types.

WEIGHT TABLE	
No. of each bug found (Column B)	Weight factor (Column C)
1–2	1
3–5	2
6–10	3
11–20	4
>20	5

Water bug recording table

MACROINVERTEBRATE TYPES			A	B	C	D
Sensitivity rating	**Taxa richness (bug types)**	**Tick if present**	**Sensitivity rating**	**Number of bugs**	**Weight factor**	**Column A x Column C**
Very sensitive	Stonefly nymph	☐	10			
	Mayfly	☐	9			
Sensitive bugs	Alderfly larva	☐	8			
	Caddisfly larva	☐	8			
	Riffle beetle and larva	☐	7			
	Water mite	☐	6			
Tolerant bugs	Beetle larva	☐	5			
	Dragonfly nymph	☐	4			
	Water strider	☐	4			
	Whirligig beetle and larva	☐	4			
	Freshwater yabby/crayfish	☐	4			
	Damselfly nymph	☐	3			
	Fly larva and pupa	☐	3			
	Midge larva and pupa	☐	3			
	Freshwater mussel	☐	3			
	Nematode	☐	3			
	Freshwater sandhopper	☐	3			
	Freshwater shrimp	☐	3			
	Water scorpion/needle bug	☐	3			
Very tolerant bugs	Diving beetle	☐	2			
	Flatworm	☐	2			
	Hydra	☐	2			
	Water treader	☐	2			
	Freshwater slater	☐	2			
	Water boatman	☐	2			
	Freshwater worm	☐	2			
	Backswimmer	☐	1			
	Bloodworm	☐	1			
	Leech	☐	1			
	Mosquito larva and pupa	☐	1			
	Freshwater snail	☐	1			
	TOTALS	☐				

Step 1: Count the number of bugs (taxa richness) **Number of bug types:** ☐

Step 2: Calculate the SPI = $\frac{\textbf{Total Column D}}{\textbf{Total Column C}}$ = ☐

Step 3: Classify the number of bug types and SPI as high or low based on your site description and the levels in the rating table:

Taxa richness (number of bug types) = ☐ **High** ☐ **Low**

SPI = ☐ **High** ☐ **Low**

Bug type and SPI rating table

Site description	SPI		Taxa richness (bug types)	
	Low	High	Low	High
Wetlands	0–3.1	>3.1	0–14	>14
Western rivers below 300 metres	0–3.1	>3.1	0–11	>11
Other rivers and creeks	0–3.5	>3.5	0–15	>15

Step 4: Identify the site conditions based on your bug count.

SPI rating table

SPI rating	Taxa richness	Site conditions based on the macroinvertebrate sample
High	High	Good water quality and a diversity of habitats. It may be a well-managed site, natural bushland or a national park.
Low	High	Water quality may be slightly affected by human activity or natural factors. There may be higher levels of salinity and/or nutrient levels at the site.
High	Low	Water quality is affected by a pollution source upstream or there are few habitats due to harsh physical conditions.
Low	Low	Water quality is affected by human use such as urban, industrial or agricultural pollution or by the downstream effects of dams.
		Unable to calculate an SPI as there are fewer than 50 macroinvertebrates in the sample. This may indicate that your site is under stress. There may be poor habitat diversity and/or water quality. Make sure you sample in all habitats and keep an eye on the site.

Step 5: If the table does not represent your site, what other factors may influence water quality at your site? .....

.....

Note: These may change over time and may include rainfall, river flow, land use, drains, condition of banks and riparian vegetation.

Appendix 6: Macroinvertebrate sampling procedures

Collecting a sample

1. Pour clear stream water into a large white sorting tray to about 2 centimetres deep and put the tray close to the edge of the water.
2. Use a short upward sweeping motion to sweep the net through the water. Make sure all habitats are sampled, including fringing vegetation, along 10 metres of stream. Sample the top, edge and bottom of the water.
3. Stop regularly to transfer the water bugs gently into the tray. Turn the net inside out and wash its top in the tray to transfer the bugs.
4. Rinse any mud or fine silt from your net. The sample should be free of sediment prior to sorting.
5. Spread the sample out in the tray so small water bugs can be seen.

Sorting the sample

1. Observe the macro invertebrates in the large white sorting tray.
2. Each group fills an ice block tray with a small amount of water.
3. Transfer bugs to the ice block trays using plastic spoons, pipettes, paintbrushes and tea strainers.
4. Sort the water bugs into the cubes in the tray, using a different cube for each type.

Identifying the species and recording results

1. An officer from the South Coast Natural Resource Management team should help you with identification of your macro invertebrates. Refer to the "Field Guide to Aquatic Macro Invertebrates of the South Coast of Western Australia".
2. Count the total number of macro invertebrates and the number of different types, record the results. The water bug survey sheet (Waterwatch, 2016) will give an indication of the health of your waterway based on the scores provided for each type of macro invertebrate and the overall number of macro invertebrates collected. The sensitivity score provides an indication of the tolerance of each macro invertebrate to water quality and is sometimes called a SIGNAL score.
3. Return macro invertebrates to the water gently, as close to the collection site as possible.

What do your results mean?

To provide an indication of water quality at your site, it is important to take into account the location of your site and whether it has flowing or standing water. Inland streams usually have a lower diversity of species than coastal freshwater streams. Wetlands will have a lower diversity than flowing water.

BIRDS

1. OVERVIEW

Students will recognise significant species of birds that use our wetlands and understand the importance of wetland habitats.

2. LINKS TO THE AUSTRALIAN CURRICULUM

Strand	Sub-strand / Key Organising Ideas
SCIENCE Science as a human endevour	Nature and development of science Use and influence of science
Science understanding	Biological sciences

3. OBJECTIVES

Students will:

- Understand that healthy wetlands support more birds.
- Be able to identify parts of birds that are important for their role.
- Identify and record different bird species found in a wetland.

4. TEACHER BACKGROUND INFORMATION

4.1 What are waterbirds?

There are many species of birds that rely on wetlands for part or all of their life cycle. These include waterfowl (ducks, geese, swans), grebes, pelicans, cormorants, crakes, rails, ibis, egrets, herons and shorebirds (waders) (Office of Environment & Heritage, 2016). Birds like the heron stalk the shallows; plovers look for food in muddy areas while grebes, ducks and cormorants feed in the open water (Enviro Active, 2016). Waterbirds depend on free standing water to feed - by swimming, diving or wading - and to establish nesting sites. Inland wet- lands also provide important habitat for waterbird species (Office of Environment & Heritage, 2016). Many species of waterbird move regularly to newly flooded habitats to feed

TOPICS
Birds
Wetlands
Adaptations
Migration
Identification

PHASES OF LEARNING
K-2, 3-6, 7-9

SITE (LOCATION)
Classroom
Internet
Wetland of your choice

ACTIVITIES
1. In class (1.5- 2 hours)
2. Excursion (2-3 hours)
3. Post excursion activities (0.5-2hrs)
4. Extra activities (1-3hrs)

MATERIALS
- 2 skipping ropes or other markers for end to represent north and south hemispheres.
- 10-15 hula hoops or 10-15 skipping ropes.
- Wetland Activity Cards.
- TV or laptop with data projector
- Camera
- Binoculars
- Birds of the Esperance Area
- Bird Adaptations Mix Up activity sheet
- Computers with internet access
- Any other books, posters or other materials to stimulate student interest

STUDENT WORKSHEET
Wetland Bird Life Observation Chart

and/ or breed before a wetland dries down. Some semi - permanent, permanent and coastal wetlands provide refuge for species when wetlands in other regions are dry for long periods (Department of Parks and Wildlife, 2016).

The following groups of waterbird species can be found in waterways across Australia:
System and Muir-Byenup System.

4.1.1 Shorebirds

Shorebirds (sometimes called waders) are commonly found on coastal shores, including beaches, rocky shores, mudflats, tidal wetlands and lagoons. Shorebirds usually feed at low- tide. As the water recedes, organisms like worms, crustaceans and molluscs need to take in oxygen so will be near the surface. Shorebirds flock to these areas and stick their beaks into the mud in a feeding frenzy (Enviro Active, 2016).

Shorebirds fly thousands of kilometres to spend the spring and summer in Australia where they take advantage of the good weather and plentiful food before travelling to their breeding grounds in the far northern hemisphere. Not all shorebirds migrate, some stay in Australia and breed on our coast. These birds are called resident shorebirds (Enviro Active, 2016). Examples of shorebirds include the Hooded Plover, Eastern Curlew, Red-necked Stint and Black-tailed Godwit.

4.1.2 Paddlers

Paddlers live in a variety of wetland habitats and the shape and size of their beak determines what type of food they eat. They have webbed feet and strong legs which make them great swimmers (Enviro Active, 2016). Examples of paddler waterbirds include the Black Swan, Chestnut Teal, Freckled Duck and Pacific Black Duck.

4.1.3 Long legged birds

Birds with long legs, long necks and long beaks are able to live in shallow waters. Long legs keeps their body above the water and their long toes help them to keep their balance in the mud. Their long beaks have different shapes which can tell you how they feed and what they might eat (Enviro Active, 2016). Examples of long legged waterbirds include the Little Egret, Yellow-billed Spoonbill, Australian White Ibis and the Brolga.

4.1.4 Reed dwellers

Shallow water near the edge of wetlands can be covered in reeds. Reeds can grow in thick dense clumps and so provide a great place for birds to hide from predators like birds of prey or foxes. The reeds are also full of invertebrates both in and out of the water and so provide plenty of food for the reed dwellers (Enviro Active, 2016). Examples of reed dweller waterbirds include the Buff-banded Rail, Australian Reed-warbler, Dusky Moorhen and Purple Swamphen.

4.1.5 Divers

Cormorants catch fish by diving in open water. Their feathers are not fully waterproof, because this would trap air under their feathers and make them float. After feeding, cormorants dry their feathers in the sun by spreading their wings (Enviro Active, 2016). Examples of diving waterbirds include the Great Cormorant, Little Black Cormorant and Australian Pelican.

4.1.6 Seabirds

Seabirds are mainly found on, over or near the ocean, but some species will also use fresh water wetlands for

feeding. They feed on the surface of the water or dive in to capture their food. Seabirds nest in colonies, often found on cliffs and islands, which helps keep their chicks safe from predators (Enviro Active, 2016). Examples of seabirds include the Short-tailed Shearwater, Wandering Albatross, Little Tern and White-faced Storm Petrel.

4.1.7 Landbirds

Many birds around wetlands rarely go on or in the water. They either live in the grass and scrubland around the wetlands or fly high above searching for food on the ground (Enviro Active, 2016).

4.2 Waterbirds in Australia and the Esperance Region

Migratory waterbirds inhabit the Australian shorelines of rivers, wetlands, oceans and lakes, where they need to rest and feed during their non-breeding season (September - March) to prepare for their annual migrations to breeding grounds in the Arctic (Office of Environment & Heritage, 2016). Migratory shorebirds in Australia travel via the East Asian – Australasian Fly- way to breed in Alaska, Siberia, Mongolia, northern China or Japan (Department of Parks and Wildlife, 2016). Stretching across 23 countries, the East Asian – Australasian Flyway is one of eight major waterbird flyways recognised around the globe (Enviro Active, 2016).

At least two million migratory waterbirds visit Australia each year during summer, of which there are more than 36 different species. The most common species of migratory birds include the Red-necked Stint, Curlew Sandpiper, Sharp-tailed Sandpiper, Bar-tailed Godwit and Green- shank (Birdlife Australia, 2016). A further 16 species visit Australia occasionally and 15 species - at least 1.1 million birds - permanently live in Australia (Department of Parks and Wildlife, 2016). To ensure the conservation of all migratory waterbirds, the Australian Government has fostered international cooperation through a range of important agreements, including the:

- Bilateral Migratory Bird Agreements with Japan (JAMBA), China (CAMBA) and the Republic of Korea (ROKAMBA),
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention),
- Ramsar Convention on Wetlands,
- Agreement on the Conservation of Albatrosses and Petrels (ACAP), and through the,
- East Asian - Australasian Flyway Partnership (Department of Environment, 2016).

The Esperance Region is home to a broad range of resident, visitor and migratory waterbirds. Their habitats vary from inland waterways, coastal wetlands, estuaries and the ocean (Birds Australia Western Australia, 2010). Many of these waterbirds are classified as uncommon and rare, notably the Little Grassbird, Blue-billed Duck, Southern and Northern Giant-Petrels, Little Egret, Glossy Ibis, Pacific Golden Plover and Masked Lapwing (Birds Australia Western Australia, 2010).

The landscape of Esperance is characterised by a broad network of ecologically significant wet- land and river systems that are important habitats for waterbirds. Two internationally significant wetland suites, Lake Warden and Lake Gore, and part of the Lake Muir system are identified as Wetlands of International Significance (under the RAMSAR Convention) (South Coast NRM, 2011). Eleven wetland systems are listed in the Directory of Important Wetlands in Australia (Environment Australia, 2001) and fifteen systems are on the Register of the National Estate (South Coast NRM, 2011).

Seven river systems in the Esperance Region, from Young River in the west through to Thomas River in the east, make up part of the Eastern South Coast aquatic bioregion (Cook et al, 2008). These diverse waterways are home to thousands of resident, visitor and migratory birds. Numerically significant waterbird species include the Black Swan, Chestnut Teal, Freckled Duck, Banded Stilt, Australian Pelican, Yellow-billed Spoonbill and the Hooded Plover (Esperance Regional Forum, 2016).

It's important to note that relative abundance doesn't always indicate the ecological significance of a waterbird species. The Hooded Plover is a threatened endemic species in Australia yet it is considered common in

Esperance as Lake Warden provides an important habitat to several hundred individual birds (Esperance Regional Forum, 2016). Similarly, the Southern Giant-Petrel is a rare species found in Esperance wetlands however its conservation status was recently upgraded from near threatened to least concern species (a species that has been evaluated by the International Union for Conservation of Nature but not qualified conservation dependant) (Wikipedia, 2016).

Threats to waterbirds in the Esperance Region

There are many different conservation issues that have an impact on waterbirds in the Esperance Region. Habitat loss and degradation are major threats to waterbird populations, exacerbated by secondary threats including climate change, disease, hunting, pollution and disturbance (CSIRO, 2016). Disturbance from people accessing waterways in the Esperance Region can affect both waterbird populations and their habitat. Predation by introduced animals such as foxes and cats are a major threat to populations and habitat modification occurs through loss of riparian vegetation, over-extraction of limited freshwater and physical alteration to river banks, channels and floodplains (South Coast NRM, 2011).

The quality of water in river systems and wetlands has a direct impact on waterbirds and their habitats. Catchment clearing and altered land use resulting in changed hydrology and in- creased salinity levels are major threats to water quality and quantity in river systems and wetlands. These land use threats can also be associated with increased erosion, sediment transportation, and altered turbidity and nutrient levels (South Coast NRM, 2011).

5. ACTIVITIES

5.1 ACTIVITY ONE: What makes a bird a bird?
In class activities. Allow 1.5 to 2 hours.

Overview:

In this activity, students will be introduced to different types of waterbirds found in the Esperance Region and will learn about their distinctive features. Students will develop an understanding of waterbird habitat and the importance of protecting significant waterways, including catchment management and water quality.

Required Resources:

- AO paper or a whiteboard for recording
- Printed copies of each of the waterbird illustrations
- One printed and laminated copy of the “hooded plover board game” per group of 3 - 4 students
- One printed copy per student of the “flyaway flag” shorebird migratory game
- A world map or atlas for each group of 3 - 4 students
- One printed copy per student of the paper bird template and folding instructions
- One printed copy per student of the “Amazing waterbird identification worksheet”
- Pencils, scissors, sticky tape, blu tac
- Dice and counters
- Copy of “Our Life the Beach” storybook

Teacher Preparation:

- Read Teacher Background Information in Waterbirds lesson plan.
- Revisit information on significant waterways in the Esperance Region from the Water Quality lesson plan (background information is provided in Section 4 of the Water Quality education program lesson plan). Re visit the information in Appendix 1 of the Water Quality lesson plan about the causes of water quality

decline and threats to habitat in the Esperance Region.

- Familiarise yourself with the different types of waterbirds that are found in the Esperance Region, back ground information is provided in Section 4 of this lesson plan. For a comprehensive list of bird species that have been sighted in Esperance over the past 30 years, download the "Birds of the Esperance Region" guide (Birds Australia Western Australia, 2010), the link is in the reference section. The preferred habitats L (lakes, wetlands, rivers), C (coastal wetlands and estuaries) and O (oceans) highlights the waterbirds in the Esperance region and the relative abundance C (common), M (moderately common), U (uncommon) and Ra (rare) highlights the size of their populations.
- Print and cut out the waterbird illustrations from Appendix 1, they will be used to illustrate the different features of birds and how these features enable them to live in different habitats.
- Print out the series of waterbird activities from Appendix 2. This includes the hooded plover board game, the "flyaway flag" shorebird migratory game and the paper bird template and folding instructions.
- Print out the "Amazing water bird identification worksheet" from Appendix 3.
- Download and print the children's storybook "Our Life the Beach" (De Mather & Tilbrook 2013), the link to download and print is in the reference section.
- Set up activity stations in the class room where students can play the hooded plover board game (in small groups), complete the "flyaway flag" shorebird migratory game (individually or in small groups), complete the bird identification worksheet and make their paper bird.

Procedure:

1. Collectively brainstorm with students what they already know about birds, have learned by watching birds and may want to know about birds. Guide students through the brainstorming process by using the following prompts:
   - What are some of the important features of birds?
   - What different types of birds are there?
   - What do you think birds eat?
   - How do birds fly?
   - Where do you think birds live?
2. Record the information on sheets of AO paper or on a whiteboard. Discuss as a class what makes birds unique to other animals.
3. Introduce your class to the different types of waterbirds that are found in the Esperance Region (shorebirds, paddlers, waders, long legged birds, reed dwellers, divers, sea birds and land birds) and their different habitats (waterways, coastal wetlands, estuaries and the ocean). Read with your class the story of "Our Life the Beach".
4. Discuss with your class the different features of waterbirds that enable them to live in their different environments (for example the spoonbill has a long beak, the duck has large webbed feet, the plover has camouflaged feathers). Using the printed images from Appendix 2, assist the class in grouping birds according to their unique features.
5. Divide students into small groups and have them complete the series of waterbird activities that are set up in activity stations around the classroom.
   -The hooded plover board game introduces students to threats that are faced by populations of shorebirds, from the nest to when they are old enough to fly. Students use a dice and counters to make their way across the board.
   -The "flyaway flag" shorebird migratory game introduces students to the complex migratory patterns of Australia's waterbirds. Students use a world map to identify the locations that migratory birds visit as they travel through the flyway from their arctic breeding grounds. Each location on the map corresponds to a letter (visible behind the pictures of the legflags) and the letters are used to complete a mystery phrase.
   -The bird identification worksheet helps students reinforce their understanding of the different features of

waterbirds that make them unique.
- The paper bird folding activity enables students to enjoy the art of origami.

6. Prompt a discussion with individual groups as they make their way around the activities to **EXPAND** their understanding of waterbird habitat, bird migration, important features of waterbirds and threats to water bird populations.

5.2 ACTIVITY TWO: Identifying waterbirds
In field activity. Allow for 2 – 3 hours (incorporating travel)

Overview:

In this activity, students will observe different species of waterbirds in their habitat.

Teacher Preparation:

- Decide on a waterway in the Esperance Region that you would like to investigate with your class. You may choose the same waterway you tested for water quality, macro invertebrates or a waterway from a different catchment.
- Revisit the different types of waterbirds and their characteristics. Background information is provided in Section 4 of this lesson plan and Appendix 1 contains illustrations and further information about ecologically significant species.
- Download the "Field Guide to Wetland Birds" from the Birdlife website, the link to down- load the guide is in the reference section. You will need several iPads for the class to access this resource; there currently isn't an android version of the guide available. Additionally you can download the "Shorebirds identification booklet" from the Birdlife website, the link is also in the reference section.
- As an alternative to using the wetland bird field guide applications, you can purchase or loan copies of a pocket guide to bird identification. Recommended guides are "The Slater Field Guide to Australian Birds" (Slater et al, 2009), "A Field Guide to Australian Birds" (Morcombe & Slater, 2000) and "The Field Guide to the Birds of Australia" (Pizzey & Knight, 2012). You can photocopy relevant sections of these guides for each small group of students. Contact the Esperance Bird Observers Group for assistance.
- Print out the bird recording worksheet from Appendix 5.

Required Resources:

- iPads, one per small group of students OR
- Pocket guides to bird identification
- Binoculars and telescopes
- Cameras
- Clipboards
- Sturdy shoes, water bottles, protective clothing
- Student worksheets to record information

Procedure:

1. Visit your chosen waterway with a representative from the Esperance Bird Observers Group to assist with viewing and identifying waterbirds. The best time of year is between November - April for migratory birds.
2. Go for a walk around the waterway, observe with the class the physical landmarks, plants, animals and any other distinguishing features. Encourage students to keep noise and disturbance to a minimum.
3. Using binoculars and telescopes, undertake waterbird sightings in small groups and record your findings on the student worksheet. Use the waterbird field guides to assist with identification of bird species.
4. Take photos of different waterbirds and their habitats for later identification. Have students listen to any bird calls and record the descriptions.

5.3 ACTIVITY THREE: Discussion of waterbird observations
In class activity. Allow 1.5 hours.

Overview:

Students will draw from learnings and field trip to discuss the waterbirds of the Esperance region./

Required Resources:

- Printed photos of waterbirds in their habitat.
- Completed waterbird identification worksheets.
- A4 paper.
- Pencils, textas, crayons.

Teacher Preparation:

- Collate the results of the bird identification worksheets and print out photos of waterbirds in their habitat.
- Revisit the information in Appendix 2 of the Water Quality education program about the causes of water quality decline and threats to habitat in the Esperance Region.

Procedure:

1. Interpret with your class the results of waterbird identification. Record the number of different species that were observed and the number of individual birds per species.
2. Review photographs that were taken on the day and discuss as a class the different populations of water birds.
3. Brainstorm in small groups the different threats to waterbird populations and their habi- tat and discuss the management actions that could be put into place to protect the area.
4. Have students draw a picture of their favourite waterbird.

VOCABULARY

Catchment: The land area which drains into a particular waterway and which is a natural topographic division of the landscape. It includes "end of catchment", where catchments join other rivers or estuaries.

Ecosystem: A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.

Estuarine: A semi-closed or periodically closed coastal body of water in which the aquatic environment is affected by the physical and chemical characteristics of both freshwater and marine systems.

Land use: Land use describes the activities that occur on land, such as agriculture, energy production, human settlements, transport, forestry, mining and conservation.

Riparian: Plant habitats and communities along the river margins and banks are called riparian vegetation.

Salinity: The accumulation of excessive salts in land and water at sufficient levels to have an impact on human and natural assets (plants, animals, aquatic ecosystems, water supplies, agriculture or infrastructure).

Turbidity: is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air.

Sedimentation: the accumulation of sand and dirt that settles in the bottom of waterways.

Waterbirds: species of birds that are ecologically dependent upon wetlands.

Water quality: Refers to the chemical, physical, biological, and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose.

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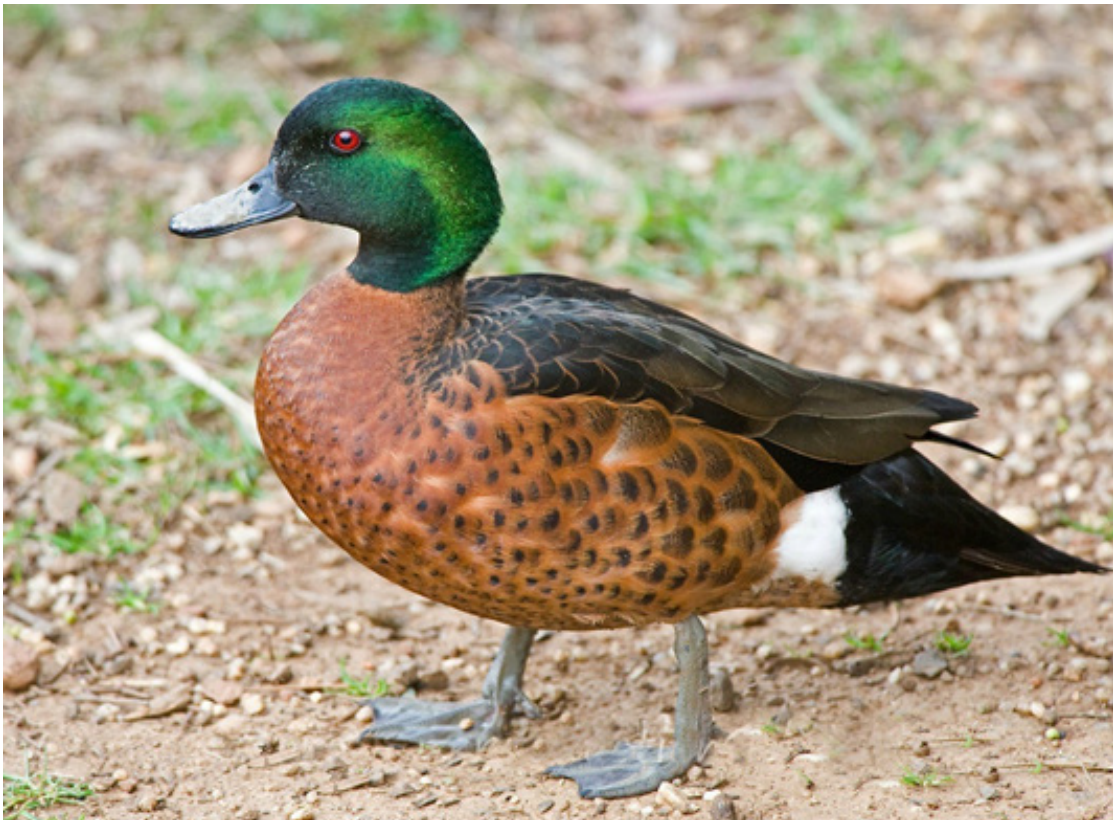
Golden Plover

Red Necked Stint



Chestnut Teal

Freckled duck

Brolga

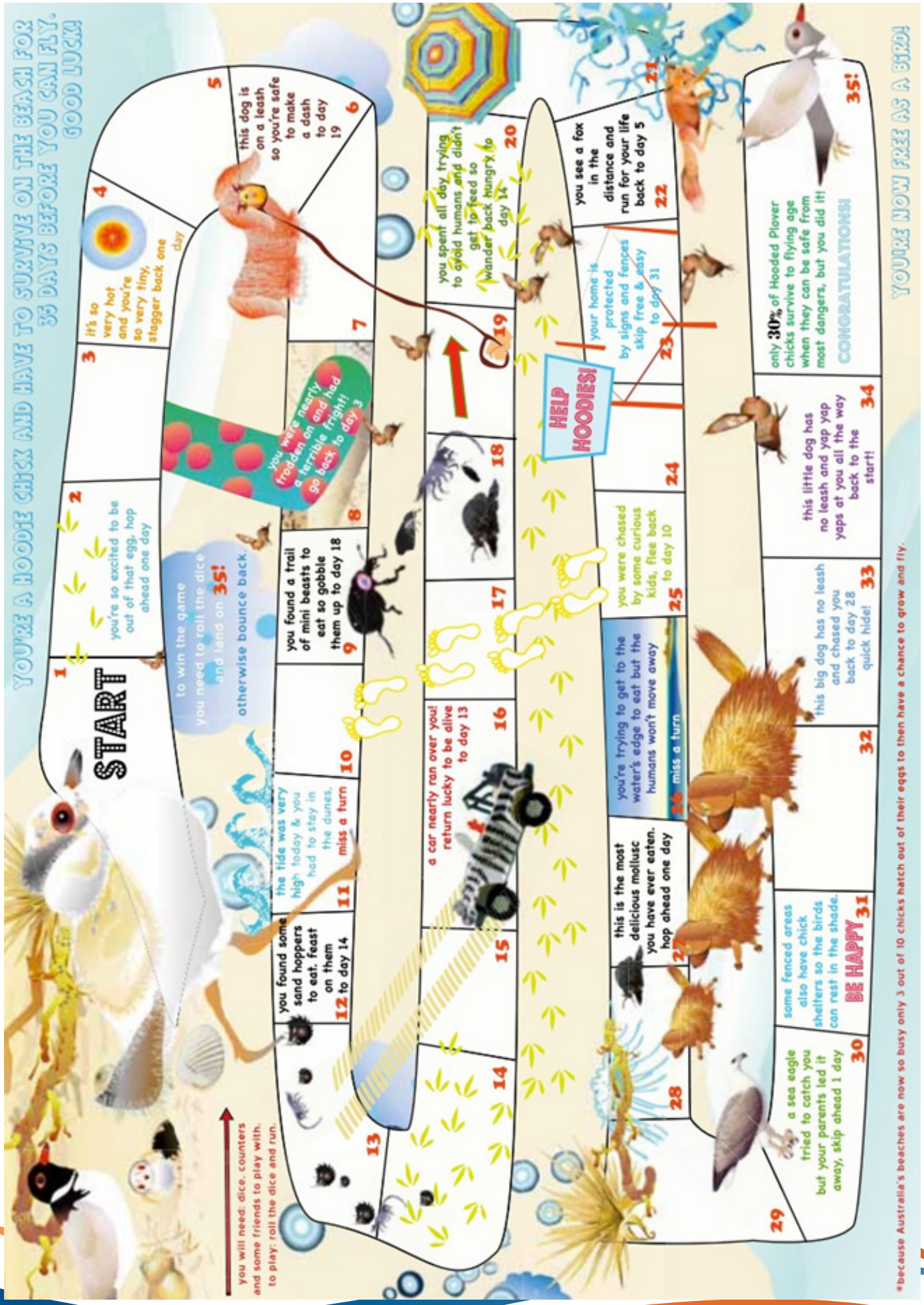
Yellow billed spoonbill

Purple Swamphen

Buff banded rail

Great Cormorant

Australian Pelican


YOU'RE A HOODIE CHICK AND HAVE TO SURVIVE ON THE BEACH FOR 35 DAYS BEFORE YOU CAN FLY. GOOD LUCK!
START
1
you're so excited to be out of that egg, hop ahead one day
2
it's so very hot and you're so very tiny, stagger back one day
3
4
this dog is on a leash so you're safe to make a dash to day 19
5
6
7
you were nearly trodden on and had a terrible fright! go back to day 3
8
you found a trail of mini beasts to eat so gobble them up to day 18
9
the tide was very high today & you had to stay in the dunes, miss a turn
10
11
you found some sand hoppers to eat, feast on them 12 to day 14
12
13
14
15
a car nearly ran over you! return lucky to be alive to day 13
16
17
18
you spent all day trying to avoid humans and didn't get to feed so wander back hungry to day 14
19
20
you see a fox in the distance and run for your life back to day 5
21
22
your home is protected by signs and fences skip free & easy to day 31
23
HELP HOODIES!
24
you were chased by some curious kids, flee back to day 10
25
you're trying to get to the water's edge to eat but the humans won't move away
26 miss a turn
this is the most delicious mollusc you have ever eaten. hop ahead one day
27
28
a sea eagle tried to catch you but your parents led it away, skip ahead 1 day
29
30
some fenced areas also have chick shelters so the birds can rest in the shade.
BE HAPPY 31
32
this big dog has no leash and chased you back to day 28 quick hide!
33
this little dog has no leash and yap yap yaps at you all the way back to the start!
34
only 30% of Hooded Plover chicks survive to flying age when they can be safe from most dangers, but you did it!
CONGRATULATIONS!
35!
YOU'RE NOW FREE AS A BIRD!
to win the game you need to roll the dice and land on 35! otherwise bounce back.
you will need: dice, counters and some friends to play with.
to play: roll the dice and run.
*because Australia's beaches are now so busy only 3 out of 10 chicks hatch out of their eggs to then have a chance to grow and fly.

Appendix 2: Paper bird folding template.

Bird

Rated: Medium

PAGE 1/2

GET CREATIVE WITH REFLEX

YOU WILL NEED

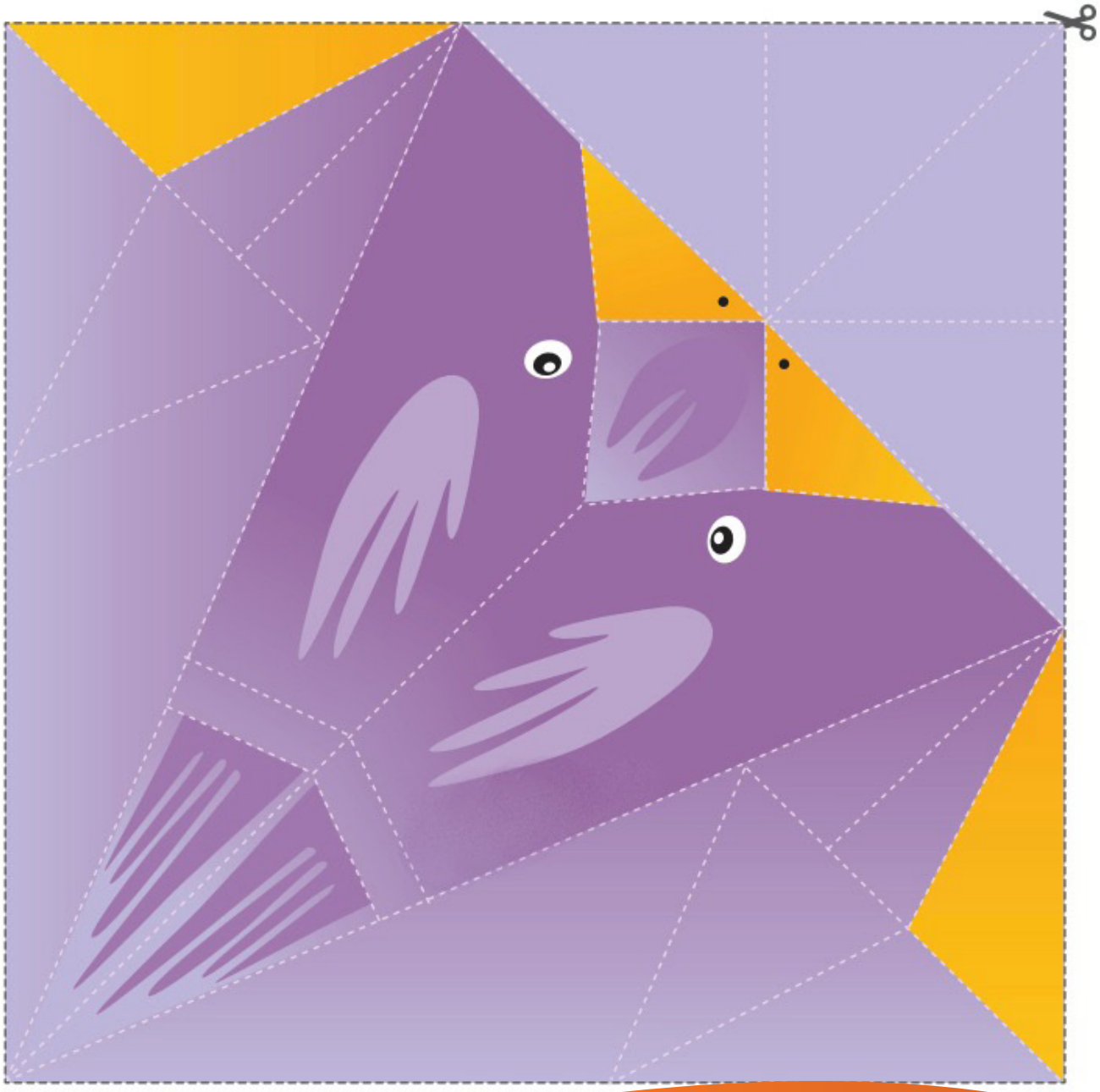
- ✓ Scissors
- ✓ 2 sheets of A4 Reflex paper

KIDS

- ✓ Get an adult to help you cut out the template and make your bird

GETTING STARTED

1. Print the template and instructions
2. Carefully cut out the template below (black dashed lines)
3. Then carefully follow the instructions on the next page to make your bird

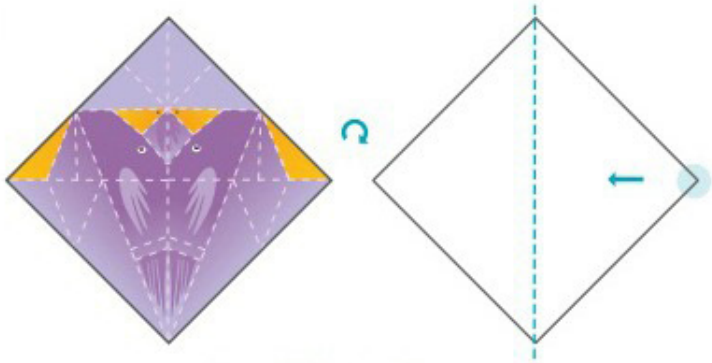


APPENDIX 2: Paper bird folding instructions:

Instructions

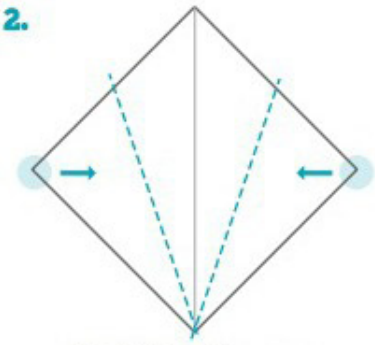
Once you have cut out the template you will have a square.
Follow the folding instructions below to make your bird.

1.



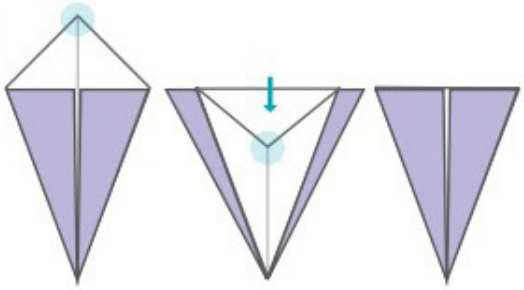
Start with the template face up, then turn over to show the blank side. Fold in half, crease and unfold.

2.



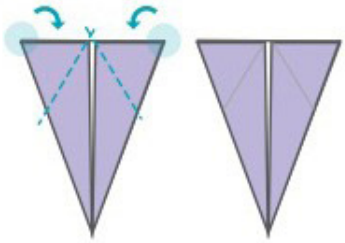
Now fold the side corners to meet in the center.

3.



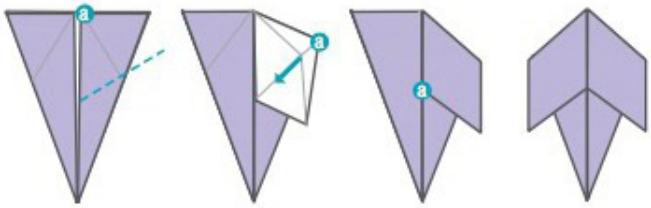
Open flaps to fold top corner down, then close flaps.

4.



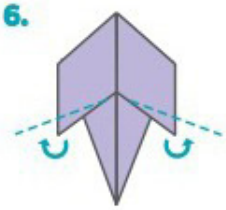
Flip over, fold top corners towards middle, crease well, then unfold.

5.



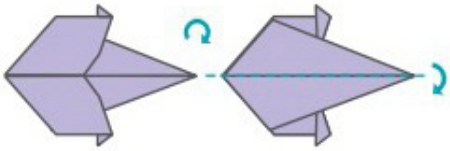
Lift the middle right corner up (a) and outward using the crease as marked. Then bring the corner back down toward the centre line and flatten. Do the same to the other side.

6.



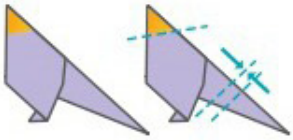
Fold the outside corners up and crease well.

7.



Rotate, flip over then fold in half from the top.

9.



Rotate, then make the creases as marked. Unfold.

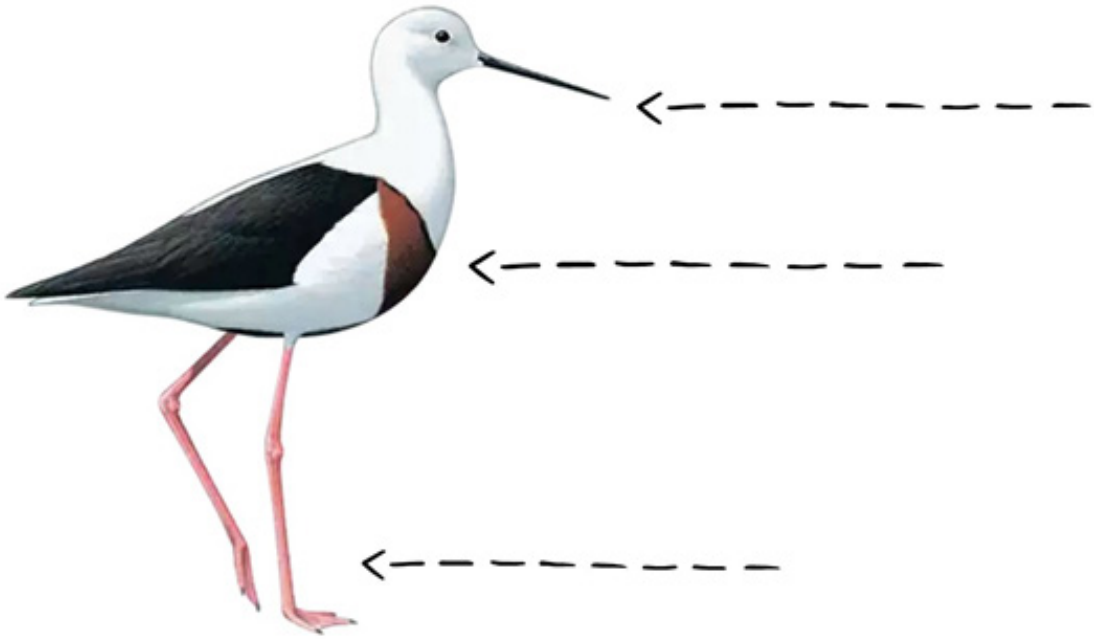
Using these creases, inside reverse fold the head, and reverse fold the tail by pushing it in.

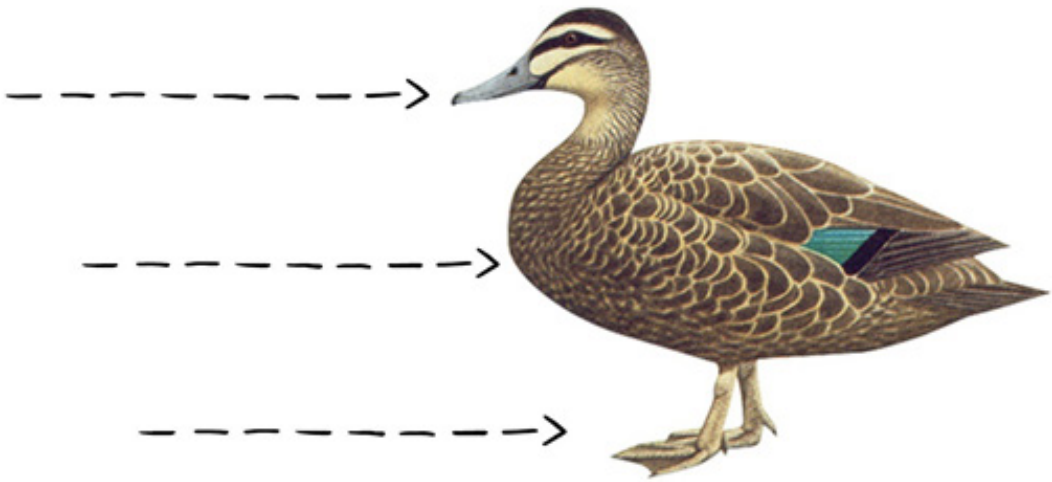
10. FINISHED

Adjust the angle of feet till bird sits steadilly.

Appendix 3: Amazing waterbirds identification worksheet

Label the different features that make the banded stilt and pacific black duck different. Write a description explaining how these two birds use their unique features in their different habitats.





Appendix 4: Wetland Bird Life Observation Chart

Date: _____ Time of Day: _____

Location: _____

SPECIES OF BIRD SIGHT- ED	NO OF BIRDS SIGHTED	ACTIVITY OF THE BIRDS

Bird Call Recognition

Sit quietly for at least five minutes and listen to the various bird calls. Write a description of what you can hear.

_____

_____

_____

_____

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CLIMATE CHANGE AND BIODIVERSITY

1. OVERVIEW

Climate change is an extremely complex and potentially distressing topic for younger students, as are many environmental topics when we talk about the health of our planet and how humans are impacting on their own habitat and that of other living organisms. The focus for the Climate Change lesson plan is to introduce the carbon cycle, the concept that humans are having an impact on the Earth's climate, some of the effects this may have and that there are many actions that we can all take as individuals in taking responsibility for looking after our environment. Many small actions can have a big impact (as of March 2016 the world's population was estimated at 7.4 billion people) so one person's actions *do matter* and this message of hope is very important to instil in the students.

2. LINKS TO AUSTRALIAN CURRICULUM

STRAND	SUB-STRAND / KEY ORGANISING IDEAS
SCIENCE Science as a human endeavour	Nature and development of science Use and influence of science
Science inquiry skills	Communicating Planning and conducting Processing and analysing data and information
Science understanding	Biological sciences

3.OBJECTIVES

The students will be able to:

- describe what carbon is,
- identify that carbon is natural and there is a carbon cycle active on Earth,
- describe that human activities are impacting on the planet, particularly biodiversity, through contributions to climate change, and
- gain an understanding of how their individual actions have a carbon footprint and that there are actions that can be taken to reduce our impacts on the environment.

TOPICS
Climate change
Carbon cycle
Carbon footprint

PHASES OF LEARNING
3-6, 7-9

SITE (LOCATION)
Classroom

ACTIVITIES
1. In class (1.5 hrs)
2. In class (1 hr)
3. In class (1 hr)

MATERIALS
- Smart board or other multimedia for viewing You Tube video.
- Copies of Appendix 1 to 12
- Markers for each game board (one per student).
- Dice (one per group).
- Pencils and erasers for each student.
- Access to internet for students (possibly 1-3 students per device/ computer) to use Trees for Life Kids Carbon
- Calculator. An alternative is to utilise the Carbon Footprint Work sheet in Appendix 13
- One sheet of A3 paper per student.
- Black paint.
- Tray for students to dip their foot into the paint.
- Soap, water and towels for students to wash and dry their feet.
- Note paper and pencil/ pen for each student.
- Coloured textas (marker pen), crayons and/ or pencils.
- Scissors and glue.
- Old magazines.

STUDENT WORKSHEET
Carbon Cycle Game Worksheet
Carbon Cycle Picture Worksheet
Carbon Footprint Worksheet

4.1 What is climate change?

Weather refers to the state of the atmosphere at a given place, at a given time (heat, humidity, cloudiness, dryness, sunshine, wind, rain, etc.). Climate is a term used to define the weather conditions that prevail in an area in general, or over a period of time.

To understand climate change, we need to be aware of the phenomenon known as the 'greenhouse effect'. The Earth is surrounded by the atmosphere which is comprised of very important gases (water vapour, carbon dioxide, nitrous oxide and methane). Some of the sunlight which hits the Earth's atmosphere is reflected by ice and clouds and some of it enters the Earth's atmosphere and is absorbed by land and water. Once it is absorbed, the energy is reemitted back into the Earth's atmosphere where some of the energy (heat) passes back into space but much of it remains trapped in the atmosphere by the greenhouse gases. So, essentially, the insulating effects of the atmospheres greenhouse gases keep the Earth warm and allow life on Earth to exist.

Climate change is a change to the properties of the climate that persist for several decades or longer. Throughout history, the Earth's climate has changed many times through natural climate change (as evidenced by studies using ice core sampling and fossils). Natural climate changes are the result of natural phenomena such as plate tectonics (resulting in volcanic eruptions), impacts from asteroids, ocean variations, changes in the sun's energy and changes in the Earth's orbit and tilt.

Today however, human activities (mainly since the industrial revolution more than two centuries ago) are directly increasing the concentrations of greenhouse gases, particularly carbon dioxide, and enhancing the greenhouse effect, this is sometimes referred to as the 'human-induced greenhouse effect'. There is clear scientific evidence that activities such as the burning of fossil fuels (for transport, manufacturing and energy production), the increased usage of nitrogen based fertilisers, land clearing (impacting on carbon dioxide absorption and storage) and increases in agricultural production to feed the worlds growing populations (further land clearing and increases in methane production) are causing a net increase in greenhouse gas emissions. The result is more heat being trapped in the atmosphere and oceans which is resulting in global warming and climate change.

To be clear, global warming is the increase in the Earth's average temperature caused by extra greenhouse gases in the atmosphere. Climate change is a broader term. It includes rising temperature due to global warming, as well as any other long-term changes in our climate that may come with it. These could be changes in the amount of rain, snow, or clouds; different wind patterns; stronger storms; and maybe even colder temperatures in some places (National Wildlife Federation, 2016).

In discussing climate change, it is essential to touch on the carbon cycle (a complex area of study in its own right) as the Earth's climate is changing as a result of the increased levels of carbon dioxide in the atmosphere. Carbon is an element that is essential for life. Carbon is the building block of life, as all living organisms are composed of carbon. Carbon atoms take many forms as they move through the environment at different rates. Carbon can be found as an organic molecule or an inorganic molecule. As carbon moves from one location (or pool) to another, many different processes can change the form of carbon. Figure 1 shows the carbon cycle recognising that some of these processes happen very quickly and others very slowly.

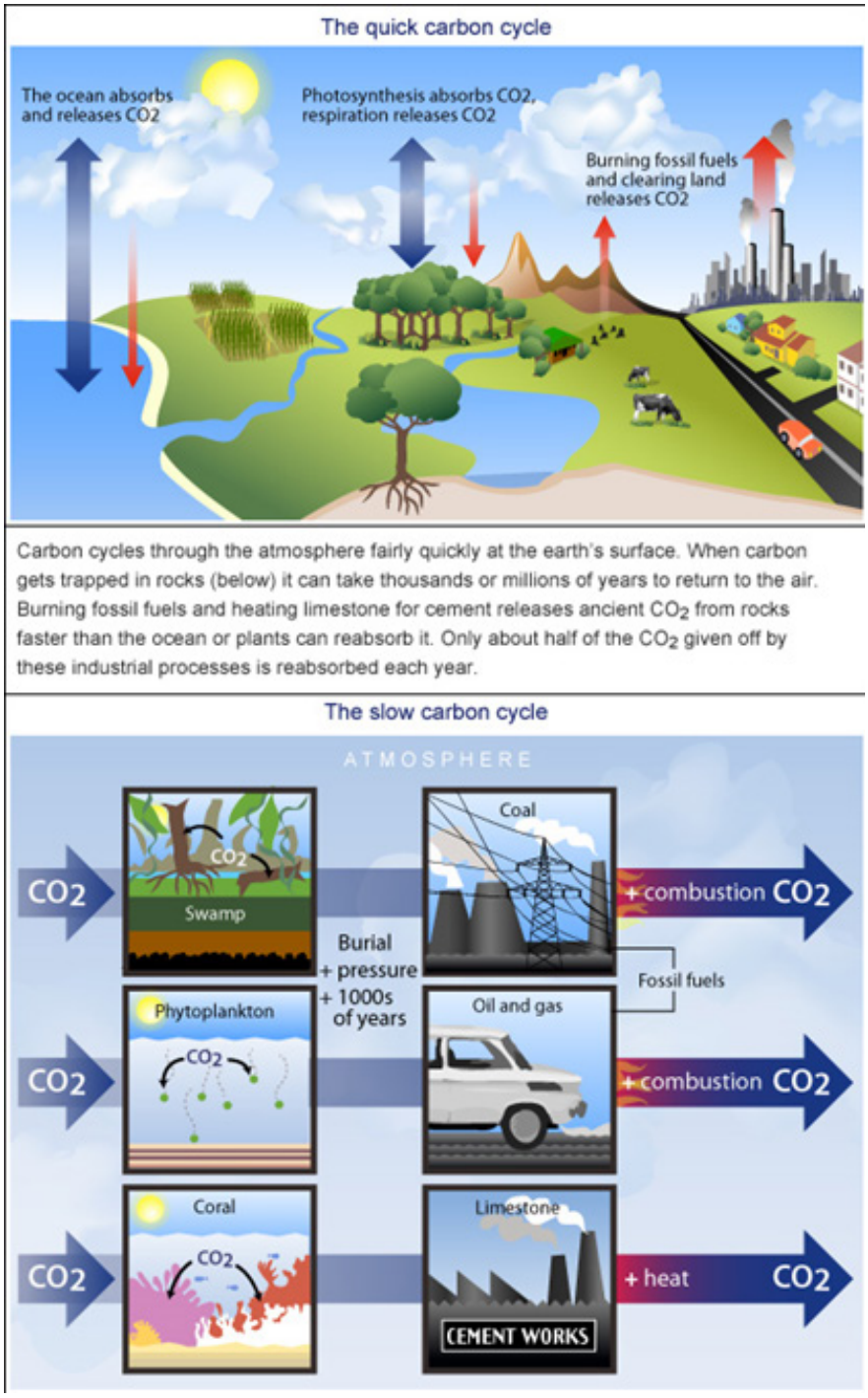

Figure 1: The carbon cycle broken into the quick carbon cycle and the slow carbon cycle (Source: Hobbs, 2015).

In building our climate change knowledge base and understanding how humans impact climate change, the term 'carbon footprint' is used. The generally accepted definition of carbon footprint is the amount of carbon dioxide, or greenhouse gases, produced as a result of our daily living, that is the actions we take and the products and services we use.

4.2 What climate changes are we observing?

Since the industrial revolution over two centuries ago, about 30 per cent of the human-induced carbon dioxide emissions have been taken up by the ocean and about 30 per cent by land vegetation. The remaining 40 per cent of emissions have led to an increase in the concentration of carbon dioxide in the atmosphere (CSIRO, 2016a). Scientists can confirm that the increased carbon dioxide is created by humans because of the increasing concentrations of carbon 12 in the atmosphere identifying that the carbon is derived from burning fossil fuels (Hanson, 2014).

4.5.1 Global warming on land

Climate change science is clear, the world is warming and human activities are the dominant cause. Much of the observed warming has occurred since the 1950s. There has been warming at the Earth's surface, warming in the lower and middle atmosphere, warming of sea-surface temperatures and warming below the ocean surface (CSIRO, 2016c). All of this indicates that the heating is not the result of changes in solar energy which would impact the upper atmosphere also.

NASA and the Unites States National Ocean and Atmospheric Agency have confirmed that 2015 was the warmest recorded year since records began in 1880 and there are early indications that 2016 is set to break more record. Today the average global temperature is 0.9°C higher than the 20th-Century average with the annual mean temperature difference as shown in Figure 2.

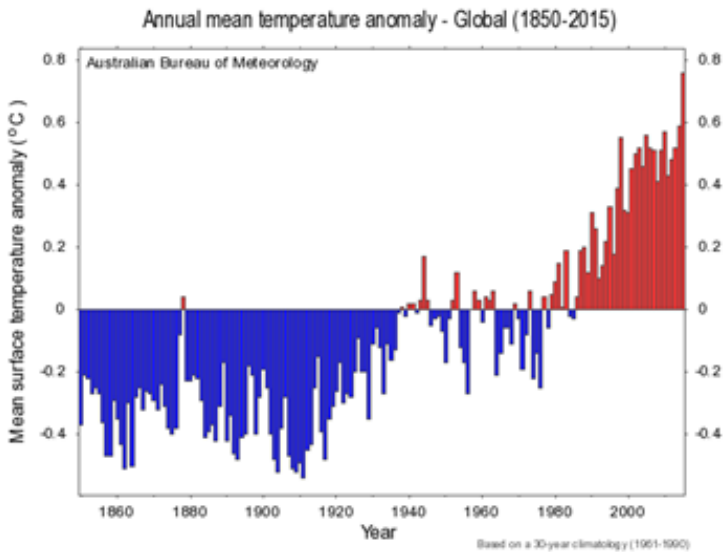

Figure 2: Annual mean global temperature anomaly 1850-2015 based on 30 year climatology (1961-1990). (Source: CSIRO 2016d).

Global warming doesn't mean temperatures are rising everywhere all the time by one degree. Temperatures in a given year or decade might rise 5 degrees in one region and drop 2 degrees in another. Exceptionally cold winters in one region might be followed by exceptionally warm summers. Or a cold winter in one area might be balanced by an extremely warm winter in another part of the globe (Carlowicz, 2016). The important message is that there is a global *average increase* in the Earth's temperature. While these increases may appear to be small, small changes to the global temperature have shown in the past to translate into big changes to the Earth's climate and natural environment (WFF, 2016b). A one-degree global change is significant because it takes a vast amount of heat to warm all the oceans, atmosphere, and land by that much. In the past, a one-to two-degree drop was all it took to plunge the Earth into the Little Ice Age. A five-degree drop was enough to bury a large part of North America under a towering mass of ice 20,000 years ago (Carlowicz, 2016).

Warming in Australia on land is consistent with warming observed across the globe in recent decades. In Australia, average air temperatures have increased by around 0.9°C since 1910, and each decade has been warmer than the previous decade since the 1950s. In Australia, seven of the ten warmest years on record have occurred since 1998 (Department of Environment, 2016b and CSIRO, 2016d).

4.5.2 Increases in ocean temperature and sea level rise

The ocean today is warmer, and sea levels are higher, than at any time since the instrumental record began (CSIRO, 2016c). Warming of the world's oceans accounts for more than 90 per cent of additional energy

accumulated from the enhanced greenhouse effect. This makes the ocean temperatures one of the most important measures for monitoring and understanding climate change (CSIRO, 2016c). The largest contributions to the warming of the oceans and global sea-level rise have been thermal expansion of the oceans (water expands as it heats) and the loss of mass from glaciers and ice sheets.

Sea-surface temperatures in the Australian region have warmed by 0.9°C since 1900. In 2013, temperatures were 0.5°C above the 1961–1990 average of 22.3°C. Sea-surface temperatures around parts of Australia have been mostly well-above average since 2010, with persistent regions of very warm to highest-on-record temperatures to the south and west of the continent throughout much of 2013 (CSIRO, 2016c).

Research undertaken by the CSIRO using a combination of historical tide-gauge data and satellite-altimeter data has to assess global averaged sea level change from 1880 to 2014 has found that during this period, global-averaged sea level rose about 23 cm, with an average rate of rise of about 1.6 mm/yr over the 20th Century (CSIRO, 2015). The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report finds that sea levels have risen by 0.19m since the beginning of the 20th century (Department of Environment, 2016c). The sea level records indicate a statistically significant increase in the rate of rise from 1880 to 2014 (CSIROc, 2015).

4.5.3 Sea ice and glacial melting

Along with increasing global and ocean temperatures, there is accelerated decreases in the mass of Greenland and Antarctic ice sheets (ice attached to land) as evidenced through science and rigorous research and monitoring (CSIRO, 2016c). There have been net decreases in glacier volumes, large reductions in Arctic sea ice (as shown in Figure 3) extent and reductions in snow cover. In this topic in particular we can see that global warming and climate change have compounding effects. Remembering that ice reflects energy from the sun, so a reduced surface area of ice from melting, the more area there is for the oceans to absorb energy (heat) from the sun.

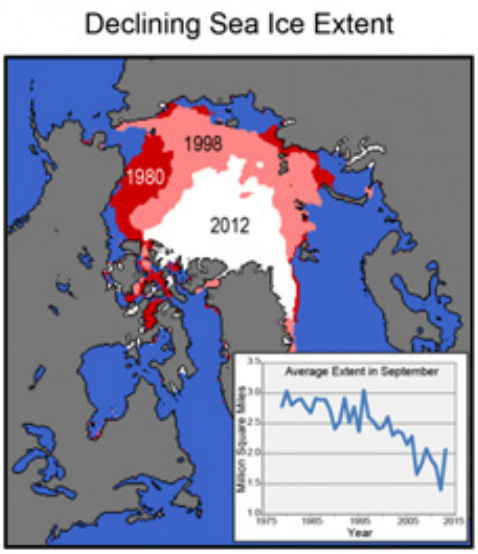

Figure 3: Declining sea ice extent in the Artic region (Source: US Global Change Research Program, 2016a)

4.5.4 Extreme weather

The extra heat in the climate system has other impacts such as affecting atmospheric and ocean circulation, which influences rainfall and wind patterns around the world. There is evidence to suggest that some types of extreme weather events are becoming more frequent and more severe, which is of particular concern in Australia given we are prone to severe events such as droughts and floods (US Global Research Program, 2016b).

4.5.5 Ocean acidification

The Earth's oceans are a sink for carbon dioxide (ie: oceans absorb and store carbon dioxide as art of the carbon

cycle). With human induced increases in carbon dioxide from fossil fuel emissions, the oceans are absorbing more carbon dioxide. As the carbon dioxide dissolves in sea water it forms a weak carbonic acid, making the ocean more acidic. Research is showing that marine organisms, shell fish and coral in particular (whose shells cannot tolerate acidic environments) are already being affected by ocean acidification.

4.3 What are the impacts of climate change, particularly on biodiversity?

Climate change is a threatening process impacting not only on biodiversity, but also to the overall health of the planet, the health and wellbeing of humans and society and the world's economies. Changes to the Earth's climate, even small changes, can have far reaching and very complex impacts.

4.3.1 Impacts on biodiversity

Climate change impacts on biodiversity have already led to observed changes in:

- the distributions of species,
- the timing of many critical life history stages (such as reaching reproductive maturity),
- plant and animal physiology,
- gender ratios,
- ecosystem net primary production, nutrient cycling, and water cycling,
- ecosystem structure and function, and
- competition, parasitism, predation, dispersal and habitat (CSIRO, 2016a).

Research undertaken by CSIRO (CSIRO, 2016a) has identified that as a result of climate change:

- Ecological change will be widespread and potentially very significant: Within decades, environments across Australia will be substantially different from those currently experienced by biodiversity at most locations. As a result, biodiversity management may need to change significantly to minimise future losses.
- Biodiversity will be impacted in many different ways: The different processes of ecological change, each driven by climate change, will combine to make prediction about the details of change and likely loss of biodiversity very difficult. As a result, managers will be faced with ongoing uncertainty about some aspects of the future changes to the systems they manage, and this will constrain the choice of options for managing biodiversity.
- There will be much spatial variation in ecological change: The spatial variation in biodiversity, in Australia's landscapes and in climate change provides many opportunities for management to facilitate the natural adaptation of biodiversity through ecological and evolutionary processes.

One pertinent and significant example of how climate change can impact biodiversity is coral reefs. Coral reefs are the nursery of the ocean and are habitat to many of the lower order marine life who in turn provide food and habitat for higher order marine animals (which humans use as a food source). Coral reefs are a fragile ecosystem and across the planet they are in decline, threatening to upset marine ecology. With global warming causing rising mean sea temperatures, increased carbon dioxide being absorbed by the oceans (resulting in ocean acidification causing leaching and coral death) and more severe weather events (essentially smashing coral reefs), there is great degree of concern and urgent action required to protect coral reefs.

4.3.2 Impacts on humans and society

Impacts related to climate change are evident across regions and in many sectors important to society such as human health, urban areas, agriculture and food security, water supply, transportation and energy. Climate change and its impacts are expected to become increasingly disruptive throughout this century and beyond (US Global Change Research Program, 2016b). Some examples of how climate change will impact on humans include:

- Coastal zones: With increasing sea levels and an increase in the potential for storm surges coastal zones will be at risk. This is particularly important in Australia, and elsewhere, given the many population centres are

located near the coast.
- Water supply: In Western Australia there has been a 15% reduction in rainfall since the mid-1970's with some modelling suggesting further declines in rainfall and therefore, runoff. With a suggested hotter and drier climate, climate change impacts to water supply for urban areas and industry will be great (Department of Environment, 2016b).
- More frequent extreme events of greater severity ie: floods, storms, droughts.
- Agriculture and food security: With climate and weather regimes being impacted by climate change, the world's food production systems are at threat.

4.3.3 Impacts on the economy

The impacts to the world's economies of climate change will include:
- Damage to property and infrastructure,
- Lost productivity,
- Mass migration and security threats, and
- Coping and adaptation costs (Union of Concerned Scientists, 2016).

4.4 Climate Change in the Australia and the Esperance Region

Australians are the highest greenhouse gas polluters, per-person, among the Organisation for Economic Co-operation and Development (OECD) populations (WWF, 2016a). In 2008, the main sources of Australia's greenhouse gas pollution were:
- 72% from energy, including stationary energy (mainly electricity generation) 51%, transport 14% and fugitive emissions (emissions from fossil fuel mining, like oil and gas production) 7%
- 15.9% from agriculture, mostly from cattle and fertilisers,
- 5.7% from industrial processes (for example, aluminium and cement production),
- 4.6% from land use, land-use change and forestry, and
- 2.6% from waste.

(WWFa, 2016)

The South Coast region of WA has a marked rainfall gradient from west to east and south to north (SCNMR, 2011). Predicated climatic changes may see this gradient shirt to the west and south with less rain inland. Annual average rainfall has declined some 20-30% in the southwest over the last couple of decades. Plants not well suited to a drier climate and a range of endemic plant and animal species, particularly threatened species, are likely to be affected by changing climatic conditions (SCNRM, 2011). The impact of sea level change on estuarine and coastal biodiversity is likely to have a marked effect on vegetation and fauna associated with these ecosystems (SCNRM, 2011).

4.5 What is being done about climate change?

Around the world there are numerous organisations, government bodies, universities, research organisation, community groups, schools and individuals undertaking a range of activities to understand what the implications are to our world, particularly to biodiversity, and taking actions to reduce our cumulative carbon footprint.

4.5.1 Global Commitments

"Global warming is a global problem and it needs a global solution. The agreement was the first critical step." Kelly O'Shanassy, Australian Conservation Foundation talking about the importance of Australia's signing of the Paris Agreement.

The international community has made a commitment to keeping global warming below 2 degrees. The United Nations Framework Convention on Climate Change (UNFCCC) provides the centrepiece for multilateral

international action to combat climate change and its impacts on humanity and ecosystems. The objective of the UNFCCC is to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". The UNFCCC sets out a framework and a process for agreeing to specific actions over time. It establishes a framework of general principles and institutions, and sets up a process through which governments meet regularly to discuss climate change action (UNFCCC, 2016a). Australia is a Party to the Climate Change Convention.

Two key international agreements have been established by UNFCCC; the Kyoto Protocol and the Paris Agreement. Australia is a Party to the Kyoto Protocol and has achieved emissions reductions in the Kyoto 1 timeframe (2008-2012) and is on track to meet its targets for Kyoto 2 (2013 to 2020) (UNFCCC, 2016b and Huffington Post, 2016). More recently, Australia signed the Paris Agreement but is yet to ratify its actions to meet its current targets of 26 to 28 percent emission reduction target by 2030. The Paris Agreement is the world's first comprehensive climate agreement to commit all countries to addressing all of the crucial areas necessary to combat climate change dealing with greenhouse gases emissions mitigation, adaptation and finance starting in the year 2020. (UNFCCC, 2016b and Huffington Post, 2016).

4.5.2 Australian Government policy

The Australian Government has a suite of policies to:

- reduce Australia's emissions,
- support clean and efficient energy,
- build resilience to the unavoidable impacts of climate change, and
- support an effective international response to climate change (Commonwealth of Australia, 2016).

4.5.3 Climate change science

Underpinning government policy on climate change is climate change science. Good quality climate change science is imperative at the international, national and local level. In order to reduce human impacts and adapt to a changing climate, we must know how and why our climate has been changing, and how and why it will change into the future. Australia has a national framework to guide climate change science and the Australian Climate Change Science Programme, which has been running continuously since 1989 (Department of Environment, 2016a).

4.5.4 Emissions reductions

Scientists agree that the worst effects of climate change can largely be avoided if carbon dioxide emissions are reduced to an acceptable level. Emissions reduction, also known as mitigation, is where governments, industries, businesses, communities and individuals take action to reduce the amount of greenhouse gas (carbon dioxide, methane and nitrous oxide) being emitted into the atmosphere. Key actions to reduce greenhouse gas emissions include:

- boosting energy productivity and efficiency,
- environmentally responsible building design,
- going carbon neutral through offset programs,
- 'Greening' transportation an urban communities,
- Employing water conservation efforts,
- increasing renewable energy,
- phasing out fossil fuel electricity,
- protecting, conserving, rehabilitating and increasing areas of vegetation and waterways, particularly native vegetation to support biodiversity and catchment health (enhancing carbon sinks),
- development of sustainable farming systems in the agricultural industry,
- exploring nuclear power,
- developing and deploying innovative low-carbon and zero-carbon technologies, and
- developing and adopting sustainable.

4.5.5 Adaptations

Adaptations refer to planning and actions that will be undertaken to allow humans to become resilient to the changes and impacts as a result of climate change. Adaptation involves taking practical actions to manage risks from climate impacts, protect communities and strengthen the resilience of the economy (Department of Environment, 2016d). In Australia we have well-established and effective natural resource management systems, mature financial, welfare and regulatory systems, well-governed institutions and internationally-renowned scientific expertise. We have developed a significant national resilience and adaptation capability (Department of Environment, 2016e and Australian Government, 2015).

Adaptations could include: changing the use of land, upgrading and hardening the design of buildings and infrastructure, adjusting activities and lifestyle, developing and implementing emergency and business continuity plans and increasing the community understanding of climate change (Australian Government, 2015).

4.5.6 Assisting biodiversity

On-ground works to assist natural systems adapt to the impacts of climate change, with particular reference to biodiversity, include:

- Protecting and establishing habitat corridors to allow plants and animals to migrate through the landscape as climate change alters environmental conditions and habitats,
- Protecting existing and identifying and recreating refuges which act as natural sanctuaries for native plants and animals.
- Building resilience to climate change by reducing the impact of other threatening processes (as outlined in the Esperance Environmental Education Biodiversity lesson plan, these include: habitat reduction and frag mentation, plant diseases, invasive species, inappropriate fire regimes etc.).
- Protecting vulnerable plant and animal species such as those with long generation times, low mobility, high specific host relationships (SCNRM, 2011).

4.5.7 What can we do as individuals?

Some simple changes that we as individuals can make to reduce our carbon footprint include:

Heating and Cooling

- Wear warm clothes in the winter instead of turning up the heat. Set your thermostat a few degrees cooler.
- Plant trees around your house for shade so you won't need as much air conditioning.

Transportation

- For short trips, try to walk or ride a bike instead of riding in a car.
- Check your family's car to be sure the tires are properly inflated. If you've ever tried to ride a bike when the tires were squishy, you'll know why cars use more gas if the tires are low on air.
- Is your family buying a new car? Choose one that gets high gas mileage to use less gas (and save money, too).

Electricity

- Turn off the lights, computer, and TV when you're not using them.
- Switch to compact fluorescent light bulbs.

4.5.8 A local example of climate change science: The Great Western Woodlands

In the north of the Esperance region is the Great Western Woodlands. This area is significant because it is the largest remaining tract of Mediterranean – climate woodland on Earth! This unique environment and its diverse ecosystems are under threat from climate change and the cumulative impacts of burgeoning developments. In recent years there has also been an increase in large, intense wildfires in the fire-sensitive semi-arid woodland ecosystems of the Great Western Woodland. The CSIRO are working with a range of other stakeholders and renowned scientists to help understand and manage this 16 million hectare woodland. Areas of activity include:

- Measuring whether old-growth woodlands are net carbon emitters or help sequester carbon from the atmosphere.
- Collecting long-term biological data to detect ecological change induced by climate, nutrient enrichment,

grazing and exotic invasions.
- Investigating the impacts of intense fires over multi-century timeframes, and assessing whether the recent high incidence of fire is unprecedented.
- Learning from and collaborating with the traditional owners— Ngadju.
- Working with students and post-doctoral fellows to address management issues such as cumulative impacts of mining exploration.

The Great Western Woodlands provide a unique opportunity to understand how relatively intact ecosystems function, respond to development and adapt to climate change. This, in turn, contributes to national and regionally significant land management issues relevant to agriculture, mining, pastoralism and biodiversity (CSIRO, 2016b)

5. SUGGESTED ACTIVITIES

ACTIVITY ONE: The carbon cycle and climate change
In class activity. Allow for 1.5 hours.

Overview:

This activity will introduce the carbon cycle and climate change to the students through students watching a You Tube video entitled The Carbon Cycle, playing the Carbon Cycle Game (Carbon Cycle Game adapted from Arizona State University: http://gk12.asu.edu/node/45, Arizona State University, 2016), watching a You Tube video entitled The Greenhouse Effect and through teacher led reflection and discussion.

Required Resources:

- Smart board or other multimedia for viewing You Tube video.
- Copies of Appendix 1 to 12 (as per teacher preparation).
- 5 markers for each game board (one per student).
- Dice (one per group).
- Pencils and erasers for each student. A clip board may be handy.

Teacher Preparation:

- Read Teacher Background Information Climate Change.
- Watch "The Carbon Cycle" You Tube video (4.23 minutes). See: https://www3.epa.gov/climatechange/kids/basics/today/carbon-dioxide.html
- Watch "The Greenhouse Effect" You Tube video (1.56 minutes). See: https://www3.epa.gov/climatechange/kids/basics/today/greenhouse-effect.html
- For each group (5 students per group) print and collate:
  - One game board: Appendix 1, this could be laminated for durability,
  - One game instructions handout: Appendix 2, there are 3 copies of the instructions on one A4 sheet, and
  - One set of game cards, printed on card stock (for durability) and cut put: Appendix 3 to 10.
  Gather a marker for each student (different small object or different colour of same object for ease of identification) and dice for each group.
- Print one copy for all students of the Carbon Cycle Game Worksheet (Appendix 11).
- Print one copy for all students of the Carbon Cycle Picture Worksheet (Appendix 12).

Procedure:

1. Show the students "The Carbon Cycle" You Tube video https://www3.epa.gov/climatechange/kids/basics/today/carbon-dioxide.html
2. Layout game boards, markers, dice and game cards.
3. Split the class into groups of 5.

4. Explain the game instructions to the students and provide each student with their Carbon Cycle Game Work sheet.
5. Students to play Carbon Cycle Game. Students should enter the locations they visit on the game board on the location blank on the Carbon Game Worksheet.
6. Allow students to play the game for the rest of the class period. If you want to continue playing the game the next day, students can start at the last pool location they entered on their worksheet. It is best if most students make it back to vegetation once before stopping the game.
7. Once the game is stopped, hand out the Carbon Cycle Picture Worksheet and have students draw their paths using arrows.
8. Discuss the carbon cycle. It is important to point out that some parts of the cycle happen over very long periods (formation of fossil fuels) of time and some happen extremely quickly (respiration). Questions that can be asked are: What is carbon? Where is carbon found in the environment? How does carbon move from one pool to another? Ask for specific processes such as photosynthesis, respiration, combustion, etc. What are some of the different forms carbon can take in the carbon cycle? Sometimes carbon is in an organic form. What does that mean? Does a carbon molecule always take the same path, or visit every pool?
9. Have the students remove all game cards where humans alter the carbon cycle. These game cards have a star in the upper right-hand corner of the card. The students can play the game again with the cards removed, and/or discuss how removing these cards would affect the carbon cycle. The students should be asked, "Which carbon pools are most influenced by human activity?"
10. Discuss that increases in the carbon dioxide concentration in the atmosphere is impacting on the Earth's climate and natural environment and that the increases are human-induced. Talk through the concept of the greenhouse effect and how increased greenhouses gases are causing global warming and climate change. Show the students "The Greenhouse Effect" You Tube video to reinforce teacher comments. https://www3.epa.gov/climatechange/kids/basics/today/greenhouse-effect.html
11. As a lead into Activity Two, ask the students to think about what they do (at home and at school) and the products that they use that may contribute to climate change.

5.2 ACTIVITY TWO: What's my carbon footprint?
In class activity. Allow for 1 hour.

Overview:

This activity will have the students reflecting on their day to day life to discover their own carbon footprint, focusing on: food, transport and energy use. The students will watch a You Tube video explaining climate change and the actions individuals can take to effect change. The students will utilise the Kids Carbon Calculator (Trees of Life, 2016) to work out and compare how much carbon dioxide their lifestyles emit in a year and then create the first part of their Carbon Footprint Poster. Adapted from Kitchen Counter Chronicles Blog (http://www.kitchencounterchronicle.com/what-is-carbon-footprint-stem-kids/).

Required Resources:

- Smart board or other multimedia for viewing You Tube video.
- Access to internet for students (possibly 1-3 students per device/ computer) to use Trees for Life Kids Carbon Calculator. An alternative is to utilise the Carbon Footprint Worksheet in Appendix 13 (Sourced: https://www.championenergyservices.com/customer-service/energy-efficiency/CarbonFootprint.pdf)
- One sheet of A3 paper per student.
- Black paint.
- Tray for students to dip their foot into the paint.
- Soap, water and towels for students to wash and dry their feet.
- Note paper and pencil/ pen for each student.

Teacher Preparation:

- Read Teacher Background Information Climate Change.

- Watch "What you can do about climate change" You Tube video. See: https://www.youtube.com/watch?v=VTfgNFz1DBM
- Visit Trees for Life website and become familiar with Kids Carbon Calculator or see Appendix 13.
- Prepare for the foot printing exercise.

Procedure:

1. Inform the students that the total amount of carbon dioxide you contribute is known as your "carbon footprint". Each individual has an impact. A small carbon footprint means you are living lightly. A big carbon footprint means you're making a big impact.
2. Show the students the "What you can do about climate change" You Tube video. See: https://www.youtube.com/watch?v=VTfgNFz1DBM
3. Reflect on the You Tube video and then lead a discussion on what activities in our everyday life result in in creases in carbon dioxide. Reflect on biodiversity prior learnings and discuss how climate change may impact on biodiversity. Some thought provoking questions could include:
   a. As the climate changes, what might animals have to do? Discuss adaptation, discuss relocation, discuss how susceptible species (ie: threatened species) may become more threatened or become extinct and that some animals may benefit (ie: invasive species).
   b. What will happen to coral reefs? Discuss that when the oceans absorb more carbon dioxide, they be come acidic. Some aquatic animals cannot tolerate this, such as shell fish and coral. What will happen to the biodiversity of a coral reef if the coral dies? What might happen to the food webs and biodiversity of the oceans if shell fish are impacted by a more acidic environment? How might this impact on human use of the oceans as a food source?
4. Have each student stamp their painted foot (make a print) on the paper (somewhere in the middle would be suitable). Set these aside to dry for later use (Activity Three). Possibly print extras for absent students.
5. Remind students that we all have a role to play in looking after our environment. Introduce students to the Kids Carbon Calculator (see: https://www.treesforlife.org.au/kids-carbon-calculator) or utilise the Carbon Foot print Worksheet (Appendix 13). Allocate internet devices/ computers to students (could be in pairs or threes) and have each student use the calculator. Advise students to take notes throughout the experience focusing on what activities they do which contribute to having a larger carbon footprint. Save these notes for Activity Three.
6. As a class come together and discuss the different activities in daily life which are contributing to increasing greenhouse gases in the atmosphere and climate change.

Teacher Preparation:

5.3 ACTIVITY THREE: Doing my bit for climate change: one person does matter!
In class activity. Allow 1 hour.

Overview:

We all have the power to make a difference and in this activity the students will reflect on what they do, the resources they use and how they may make some relatively small changes in their lives to have a lighter carbon footprint. Students will develop a Carbon Footprint Poster (using the painted butchers paper form Activity Two) and links will be made to how these changes could assist the planet by reducing greenhouse gas emissions.

Required Resources:

- Smart board or other multimedia for viewing You Tube video.
- Coloured textas (marker pen), crayons and/ or pencils.
- Scissors and glue.
- Old magazines.
- Carbon Footprint Poster (as prepared in Activity Two) for each student.

Teacher Preparation:

- Read Teacher Background Information Climate Change.
- Watch "What you can do about climate change" You Tube video (9.59 minutes).

Procedure:

1. Have all of the students collect their carbon footprints and outline the objective of this activity (make a Carbon Footprint Poster).
2. Revisit climate change key issues: greenhouse effect and how humans are impacting by increasing carbon dioxide in the atmosphere. All biodiversity (including humans) will be impacted by climate change.
3. Discuss the range of research (climate change science) and actions which are being taken across the globe through all levels of society to find out more about what is happening to the Earth's climate and how we as humans can reduce emissions and make changes to our industries, economies and societies to adapt to cli mate change and assist the earths biodiversity to cope better with the change through works such as pre serving and conserving habitats, controlling invasive species and undertaking waterway rehabilitation.
4. Show the "What you can do about climate change" You Tube video to the students. https://www.youtube.com/watch?v=VTfgNFz1DBM
5. Have students decorate their poster with actions and things that increase greenhouse gases in our atmosphere and contribute to climate change (in top section) and actions and things that can decrease our carbon footprint (in the bottom section). Encourage children to show there is a difference between high carbon footprint activities and low carbon footprint activities (ie: using different dominant colours). Students could use cut outs from old magazines to assist in the decorating.
6. Display Carbon Footprint Posters and have students talk through their posters.
7. Remind students that while climate change is a global issue and we are all individuals, our actions can all have an impact and with over 7.4 billion people on the planet, our individual actions can have a big impact.

FURTHER READING

The Climate Institute - http://www.climateinstitute.org.au/

Climate Kids: http://climatekids.nasa.gov/

Bureau of Meteorology – Australia's national weather, climate and water agency http://www.bom.gov.au/

CSIRO – Australia's national research body and a world leader in climate research. http://www.csiro.au/

Intergovernmental Panel on Climate Change – The group of thousands of experts advising the world's governments on climate change. http://www.ipcc.ch/

The Center for Research on Environmental Decisions, Columbia University – Understanding how people understand climate change. http://cred.columbia.edu/

Skeptical Science – a guide for the sceptical and perplexed; busting the myths with science. http://www.skepticalscience.com/

NASA – America's space agency conducts cutting-edge climate research, with excellent educational material. http://www.nasa.gov/

The US National Oceanic & Atmospheric Administration – Rich resource on anything related to climate change, including a helpful animated time history of CO_2 over the last 800,000 years. http://www.noaa.gov/

The Met Office – The UK's national climate and weather service. http://www.metoffice.gov.uk/

Digital Media

In addition to the videos linked with the suggested activities, here are some further resources.

Title and Description	At
"What is Climate Change" A 2.37min You Tube video produced by the Great Barrier Reef Marine Park Authority briefly outlining what Climate Change is, its impact on the biodiversity of coral reefs and what individuals can do reduce their carbon footprint.	https://www.youtube.com/watch?v=ko6G-NA58YOA
"Climate Change According to a Kid" A 2.12 minute You Tube animation produced by Rappler showing how a 12 year old (or younger) may see it.	https://www.youtube.com/watch?v=Sv7OHf-pIRfU
"Understanding the UNFCCC" A 2.00min image clip video with narration about change in the environment and how we as humans have pressured the natural environment, that we need to change to reinstate the natural balance and that we have everything we need to change.	http://bigpicture.unfccc.int/content/understanding-the-unfccc.html

VOCABULARY

Climate Change: a change in climate and weather patterns over time.

Global warming: warming trend of Earths land and sea surfaces.

Greenhouse gases: gases in the atmosphere necessary for life on Earth to be sustained.

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Carbon Cycle Game Worksheet

Station 1 **Pool**: Vegetation **Beginning Form:** _____ **Process**: _____ **End Form**: _____	***Station 6*** **Pool**: _____ **Beginning Form:** _____ **Process**: _____ **End Form**: _____
Station 2 **Pool**: _____ **Beginning Form:** _____ **Process**: _____ **End Form**: _____	***Station 7*** **Pool**: _____ **Beginning Form:** _____ **Process**: _____ **End Form**: _____
Station 3 **Pool**: _____ **Beginning Form:** _____ **Process**: _____ **End Form**: _____	***Station 8*** **Pool**: _____ **Beginning Form:** _____ **Process**: _____ **End Form**: _____
Station 4 **Pool**: _____ **Beginning Form:** _____ **Process**: _____ **End Form**: _____	***Station 9*** **Pool**: _____ **Beginning Form:** _____ **Process**: _____ **End Form**: _____
Station 5 **Pool**: _____ **Beginning Form:** _____ **Process**: _____ **End Form**: _____	***Station 10*** **Pool**: _____ **Beginning Form:** _____ **Process**: _____ **End Form**: _____

You are carbon in the form of CO_2. You are taken up by the plant for photosynthesis. Go to the **VEGETATION** pool. **Beginning Form**: CO_2 **Process**: Photosynthesis **End Form**: Carbohydrate	You are carbon in the form of CO_2. You stay in the atmosphere. Lose a turn. **Beginning Form**: CO_2 **Process**: None **End Form**: CO_2	You are carbon in the form of CO_2, and you enter the ocean. Go to the **OCEAN** pool. **Beginning Form**: CO_2 **Process**: Chemical Form Change **End Form**: Bicarbonate
You are carbon in the form of CO_2. You are taken up by the plant for photosynthesis. Go to the **VEGETATION** pool. **Beginning Form**: CO_2 **Process**: Photosynthesis **End Form**: Carbohydrate	You are carbon in the form of CO_2. You stay in the atmosphere. Lose a turn. **Beginning Form**: CO_2 **Process**: None **End Form**: CO_2	You are carbon in the form of CO_2, and you enter the ocean. Go to the **OCEAN** pool. **Beginning Form**: CO_2 **Process**: Chemical Form Change **End Form**: Bicarbonate

You are carbon that has been used by the bacteria and fungi for energy through respiration. Go to the **ATMOSPHERE** pool as CO_2. **Beginning Form**: Carbohydrate **Process**: Respiration **End Form**: CO_2	You are carbon in the body of the bacteria and fungi. You continue to grow. You remain in the **BACTERIA & FUNGI** pool. Lose a turn. **Beginning Form**: Organic Matter **Process**: Growth **End Form**: Organic Matter	You are carbon in the body of the bacteria and fungi. You die and go to the **LITTER & WASTE** pool. **Beginning Form**: Organic Matter **Process**: Death **End Form**: Organic Matter
You are carbon that has been used by the bacteria and fungi for energy through respiration. Go to the **ATMOSPHERE** pool as CO_2. **Beginning Form**: Carbohydrate **Process**: Respiration **End Form**: CO_2	You are carbon in the body of the bacteria and fungi. You continue to grow. You remain in the **BACTERIA & FUNGI** pool. Lose a turn. **Beginning Form**: Organic Matter **Process**: Growth **End Form**: Organic Matter	You are carbon in the body of the bacteria and fungi. You die and go to the **LITTER & WASTE** pool. **Beginning Form**: Organic Matter **Process**: Death **End Form**: Organic Matter

You are carbon in the form of fossil fuels. It is many years until you are discovered. Lose a turn. **Beginning Form**: Fossil Fuels **Process**: Storage **End Form**: Fossil Fuels	You are carbon in the form of fossil fuels. You are discovered and removed from the earth. Go to the **INDUSTRY & VEHICLE** pool. **Beginning Form**: Fossil Fuels **Process**: Mining **End Form**: Fossil Fuels ★
You are carbon in the form of fossil fuels. It is many years until you are discovered. Lose a turn. **Beginning Form**: Fossil Fuels **Process**: Storage **End Form**: Fossil Fuels	You are carbon in the form of fossil fuels. You are discovered and removed from the earth. Go to the **INDUSTRY & VEHICLE** pool. **Beginning Form**: Fossil Fuels **Process**: Mining **End Form**: Fossil Fuels ★

Game Instructions

1. Sort the game cards by heading, and pick a game piece.
2. Place game pieces at vegetation.
3. Roll the dice to see who starts. The player with the highest number starts. Continue in a clockwise direction after the first player has been determined.
4. Begin by picking a vegetation card. Read the card to find out your next destination, and then roll the dice to find out how many spaces you move towards your destination. Record the appropriate information from each card to your worksheet.
5. When you return to vegetation again, pick up a second game piece, and continue on.
6. The first person to reach vegetation again, wins the game.

Game Instructions

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2. Place game pieces at vegetation.
3. Roll the dice to see who starts. The player with the highest number starts. Continue in a clockwise direction after the first player has been determined.
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5. When you return to vegetation again, pick up a second game piece, and continue on.
6. The first person to reach vegetation again, wins the game.

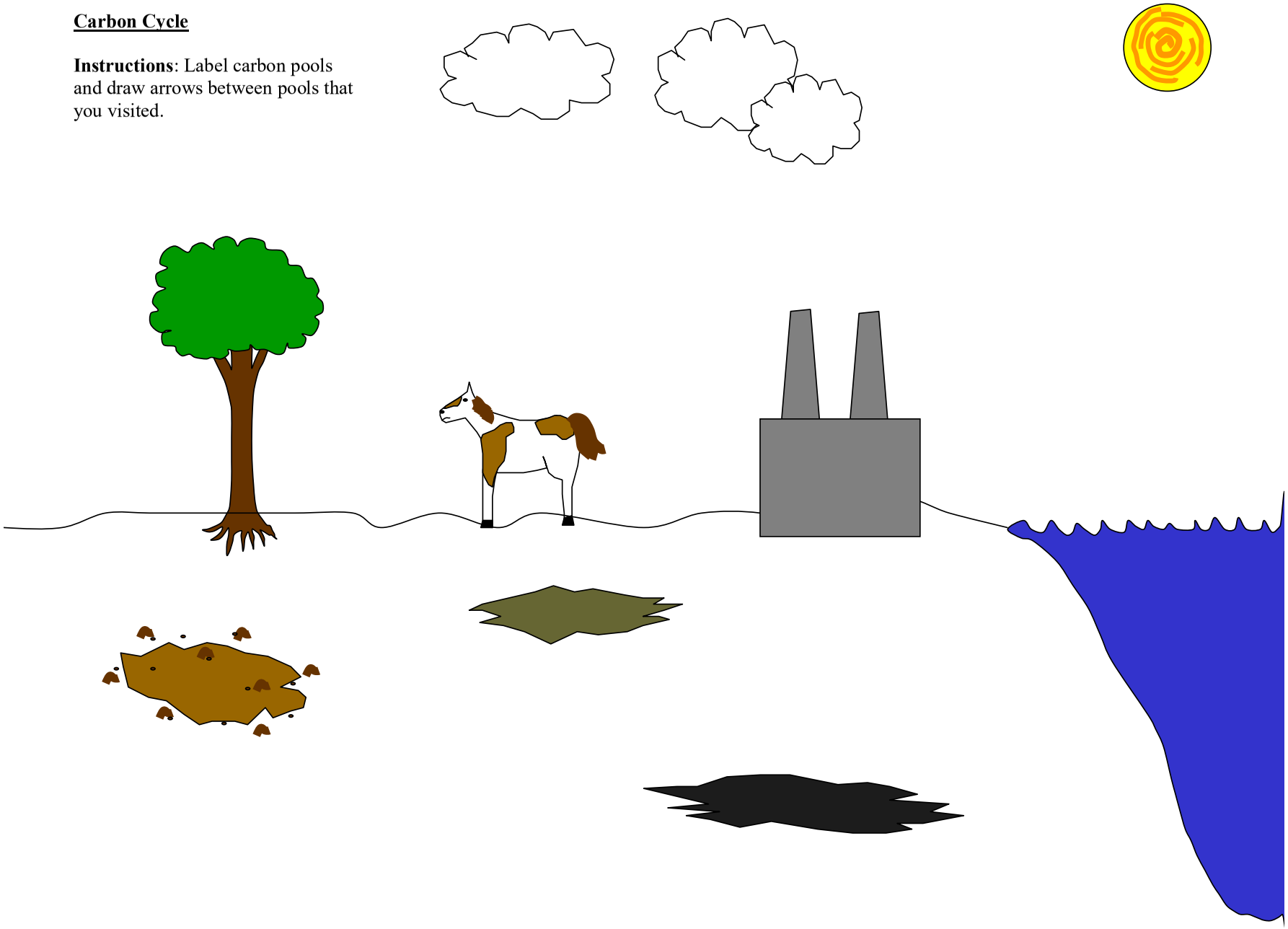
You are carbon in the form of coal (fossil fuels). You are burned in a power plant. You now go to the **ATMOSPHERE** pool as CO_2. **Beginning Form**: Fossil Fuels **Process**: Combustion **End Form**: CO_2	You are carbon in the form of gasoline (fossil fuels). You are burned in a car. You now go to the **ATMOSPHERE** pool as CO_2. **Beginning Form**: Fossil Fuels **Process**: Combustion **End Form**: CO_2
You are carbon in the form of coal (fossil fuels). You are burned in a power plant. You now go to the **ATMOSPHERE** pool as CO_2. **Beginning Form**: Fossil Fuels **Process**: Combustion **End Form**: CO_2	You are carbon in the form of gasoline (fossil fuels). You are burned in a car. You now go to the **ATMOSPHERE** pool as CO_2. **Beginning Form**: Fossil Fuels **Process**: Combustion **End Form**: CO_2

You are carbon in the form of organic material that cannot be broken down by bacteria or fungi. You stay in the litter & waste pool. Lose a turn. **Beginning Form**: Organic Matter **Process**: Humification **End Form**: Organic Matter	You are carbon in the form of organic material. You are broken down by bacteria & fungi. Go to the **BACTERIA & FUNGI** pool. **Beginning Form**: Organic Matter **Process**: Decomposition **End Form**: Inorganic Carbon	You are carbon in the form of dead plants and animals. You are covered quickly by soil and buried. Go the **FOSSIL FUEL** pool. **Beginning Form**: Organic Matter **Process**: Pressurization **End Form**: Fossil Fuels
You are carbon in the form of organic material that cannot be broken down by bacteria or fungi. You stay in the litter & waste pool. Lose a turn. **Beginning Form**: Organic Matter **Process**: Humification **End Form**: Organic Matter	You are carbon in the form of organic material. You are broken down by bacteria & fungi. Go to the **BACTERIA & FUNGI** pool. **Beginning Form**: Organic Matter **Process**: Decomposition **End Form**: Inorganic Carbon	You are carbon in the form of dead plants and animals. You are covered quickly by soil and buried. Go the **FOSSIL FUEL** pool. **Beginning Form**: Organic Matter **Process**: Pressurization **End Form**: Fossil Fuels

You are carbon in the form of bicarbonate (baking soda). You are stored in the ocean. Lose a turn **Beginning Form**: Bicarbonate **Process**: Storage **End Form**: Bicarbonate	You are carbon in the form of bicarbonate (baking soda). You are released into the atmosphere as CO_2. Go to the **ATMOSPHERE** pool. **Beginning Form**: Bicarbonate **Process**: Chemical Form Change **End Form**: CO_2
You are carbon in the form of bicarbonate (baking soda). You are stored in the ocean. Lose a turn **Beginning Form**: Bicarbonate **Process**: Storage **End Form**: Bicarbonate	You are carbon in the form of bicarbonate (baking soda). You are released into the atmosphere as CO_2. Go to the **ATMOSPHERE** pool. **Beginning Form**: Bicarbonate **Process**: Chemical Form Change **End Form**: CO_2

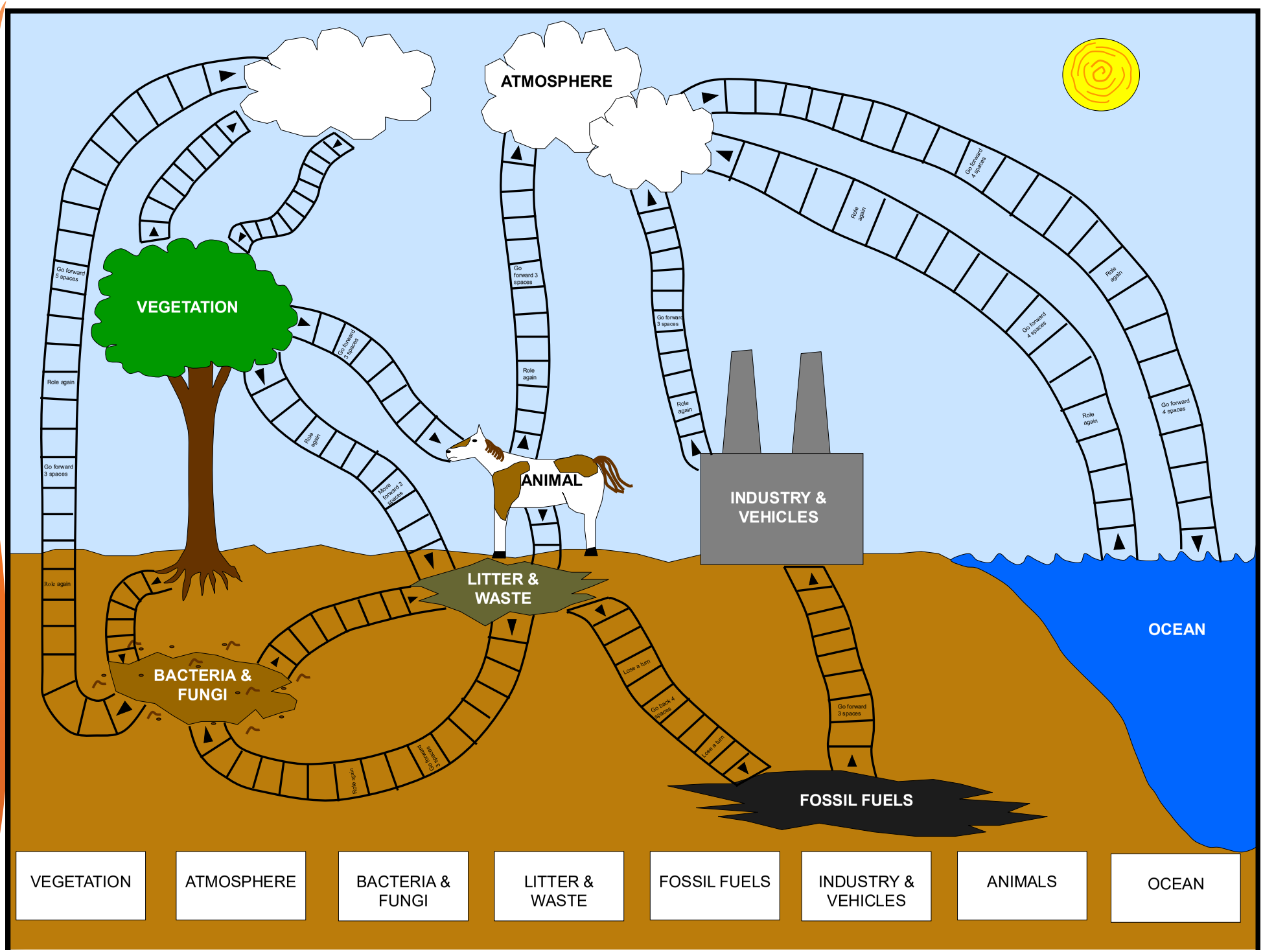
Carbon Cycle

Instructions: Label carbon pools and draw arrows between pools that you visited.



You are a sugar in the plant that goes through respiration to provide energy to the plant and now you go to the **ATMOSPHERE**. **Beginning Form**: Carbohydrate **Process:** Respiration **End Form:** CO_2	You are now sugars in the leaf that have been eaten by an animal. Go to the **ANIMAL** pool. **Beginning Form:** Carbohydrate **Process**: Consumption **End Form:** Organic Matter	You are sugars that are being stored in the plant. You lose a turn. **Beginning Form:** Carbohydrate **Process**: Storage **End Form:** Carbohydrate
You are carbon in a leaf that has fallen off of the tree. Go to the **LITTER & WASTE** pool. **Beginning Form:** Carbohydrate **Process**: Death **End Form:** Organic Matter	You are carbon in the form of sugars given off by the roots to feed bacteria and fungi to provide nutrients. Go to the **BACTERIA & FUNGI** pool. **Beginning Form:** Carbohydrate **Process**: Consumption **End Form:** Organic Matter	You are carbon that has been released by burning the plant. Go to the **ATMOSPHERE** as CO_2. **Beginning Form**: Carbohydrate **Process:** Combustion **End Form:** CO_2

You are carbon in the form of sugar and you go through respiration to provide the animal with energy. Go to the **ATMOSPHERE** as CO_2. **Beginning Form:** Carbohydrate **Process**: Respiration **End Form:** CO_2	You are carbon that was unable to be digested by the animal. Go to the **LITTER & WASTE** pool. **Beginning Form**: Organic Matter **Process**: None **End Form**: Organic Matter	You are carbon that has become part of the body of the animal. Lose a turn. **Beginning Form:** Organic Matter **Process**: Storage **End Form:** Organic Matter
You are carbon in the body of the animal and you die. Go to the **LITTER & WASTE** pool. **Beginning Form:** Organic Matter **Process**: Storage **End Form:** Organic Matter		


ATMOSPHERE
VEGETATION
ANIMAL
INDUSTRY & VEHICLES
LITTER & WASTE
BACTERIA & FUNGI
FOSSIL FUELS
OCEAN
Go forward 5 spaces
Role again
Go forward 3 spaces
Role again
Go forward 2 spaces
Role again
Move forward 2 spaces
Go forward 3 spaces
Role again
Go forward 3 spaces
Role again
Go forward 4 spaces
Role again
Go forward 4 spaces
Role again
Go forward 4 spaces
Lose a turn
Go back 4 spaces
Lose a turn
Go forward 3 spaces
Role again
Go forward 5 spaces
VEGETATION
ATMOSPHERE
BACTERIA & FUNGI
LITTER & WASTE
FOSSIL FUELS
INDUSTRY & VEHICLES
ANIMALS
OCEAN

Carbon Footprint Worksheet

CHAMPION ENERGY SERVICES.COM

Circle the letter that best answers the following questions, and then use the Scoring Instructions to calculate your "carbon footprint" – the effect your family has on the climate in terms of greenhouse gasses you produce measured in units of carbon dioxide.

1. How do you get to school?
A. Walk or ride your bike
B. Motorcycle
C. Car
D. Bus or van

2. What kind of vehicle(s) do your parents drive?
A. None (Don't own a vehicle)
B. Motorcycle only
C. Car
D. SUV, van or truck

3. How often does someone in your family fly in a plane?
A. Less than once per month
B. Once per month
C. 2 to 4 times per month
D. Once or more per week

4. How often does your family eat out or order food at a restaurant?
A. Never
B. Once per month
C. Once per week
D. Twice or more per week

5. What kind of food does your family eat?
A. Home grown or raised
B. Combination of store bought and home grown
C. Store bought only

6. How many carbonated drinks (soda or pop) do you drink?
A. None
B. 1 can per day
C. 2 cans per day
D. 3 or more cans per day

7. How often does your family do laundry?
A. Once per month
B. Twice per month
C. Once per week
D. Twice or more per week

8. Do you get newspapers or magazines at home?
A. Yes
B. No

9. Do you turn the lights off when not needed?
A. Yes
B. No

10. Do you turn off your computer, video games or other electronics when you're not using them?
A. Yes
B. No

11. What type of fuel or energy is used to heat your home?
A. Wood
B. Propane
C. Oil
D. Natural gas

12. Does anyone in your home own any of the following items? (Circle all that apply.)
A. TV
B. Cell phone
C. DVD player
D. Computer
E. Washing machine
F. Dishwasher
G. Refrigerator
H. Motorcycle, snowmobile. quad
I. Motorboat

SCORING INSTRUCTIONS: For questions 1 through 11, assign 1 point for each A answer, 2 points for each B, 3 points for each C and 4 points for each D. For question 12, assign 1 point for each item circled. Add the points together to determine your "carbon footprint."

13 – 20 Points:
Green is your favorite color. Keep up the good work.

21 – 28 Points:
Very good.

29 – 36 Points:
Your efforts are appreciated.

36 – 43 Points:
There's room for improvement.

44 – 46 Points:
Look for ways to become better friends with Mother Nature.

A Note About Your Carbon Footprint
As this worksheet shows, the more you consume, the greater your carbon footprint. Each time something is consumed, the earth's natural resources are used. By knowing your carbon footprint, you can understand how the earth is impacted and identify ways to protect natural resources.

Printed on recycled paper

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