YEARS 11&12

# ENVIRONMENTAL SCIENCE

## TEACHING & LEARNING SUPPLEMENT

INDEPENDENT SCHOOLS TASMANIA

TASMANIAN CATHOLIC education office

Tasmanian Government

Teaching and Learning Supplement

# ENVIRONMENTAL SCIENCE (ESS315118)

## ADVICE FOR TEACHERS

This document helps to describe the nature and sequence of teaching and learning necessary for learners to demonstrate achievement of course outcomes.

It suggests appropriate learning activities to enable learners to develop the knowledge and skills identified in the course outcome statements.

Tasks should provide a variety and the mix of tasks should reflect the fact that different types of tasks suit different knowledge and skills, and different learning styles. Tasks do not have to be lengthy to make a decision about learner demonstration of achievement of an outcome.

## COURSE SPECIFIC ADVICE

This *Environmental Science, Level 3* Teaching and Learning Supplement must be read in conjunction with the Environmental Science level 3 course document and relevant External Assessment Specifications and Examination Guidelines.

It contains advice to assist teachers delivering the course and can be modified as required. This Teaching and Learning Supplement is designed to support teachers new to or returning to teaching this course. The practical component of this course may include off campus experiences.

For the content areas of Environmental Science, three interrelated strands - Science Inquiry Skills; Science as a Human Endeavour; and Science Understanding will be integrated into all sections of study.

Science Inquiry Skills are common to all TASC science courses and are contextualised for each discipline.

Practical investigation, interpretation of data and reflecting on experimental design are used as a means of teaching and consolidating the course content as well as a means of assessment.

The application and impact of *Environmental Science* in society is also an integral part of the course.

## COURSE CONTENT

Specific teaching advice is given in this supplement about of the following criteria:

| | Content or process for criterion | Sequence |
|---|---|---|
| Criterion 2 | develop, interpret and analyse experiments and investigations | For use throughout the course in conjunction with criteria 4 to 8 |
| Criterion 4 | analyse the application and impact of environmental science in society | |
| Criterion 5 | apply ecological concepts and processes | Content can be delivered in any particular order |
| Criterion 6 | apply concepts and processes of ecosystem change | |

| | Content or process for criterion | Sequence |
|---|---|---|
| Criterion 7 | apply concepts relating to human dependence and impact on ecosystems | |
| Criterion 8 | apply principles and processes related to ecologically sustainable management of the environment | |

*Environmental Science 3* has a complexity of TASC level 3 and a design time of 150 hours. Content is divided into four sections; relating directly to Criteria 5 to 8, respectively, in the course. The order of delivery of the content is not prescribed. Each of the five content sections is compulsory and learners must participate in a minimum of 30 hours of practical activities. Learning activities for Criteria 2 and 4 should be related to and support one or more of the four content areas.

# TEACHING AND LEARNING

## Develop, interpret and analyse experiments and investigations

### Criterion 2 *Examples of learning activities*

Experimental design

Learners:

convert the following research questions into hypotheses, and outline a methodology for their testing:

- do pesticides also kill plants?
- does salination lead to desertification?

collect scientific data that provides evidence of an organisation's environmental management strategies; comment on how validity, accuracy and reliability of the data has been demonstrated

Investigate:

- is there a correlation between levels of carbon dioxide in an aqueous solution and the rate of dissolution of the calcium carbonate in marine shells?
- what factors affect productivity (eg temperature, nutrients, water availability)
- how do fire, drought and flood affect the relative regeneration rates of native and introduced plant species? (see Detailed Example below)

collect field data for three environmental indicators within a local ecosystem; compare data collected with geographically comparable water quality data collected; account for differences in data collected; identify possible limitations of data collection methodology; and suggest realistic improvements

design and conduct experiments that extend investigations related to environmental science field sampling methods, for example:

- is the use of a transect line or a quadrat more appropriate for determining organism populations in a rocky shore system?
- develop hypotheses and design and conduct experiments to investigate threats to biodiversity, for example:
- how does the concentration of acid (acid rain) affect the germination rate of radish seeds?
- how does the concentration of salt (salinity of water) affect the growth of the common freshwater algae freshwater, Chlorella (as a potential source of biomass/biolipid)?

formulate a hypothesis and plan and undertake an investigation to determine how:

- change an abiotic factor (for example, light intensity, temperature, salinity) affects the sustainability of a closed ecological chamber (for example, a bottle ecosystem) as measured by the population size of a macroinvertebrate (for example, Daphnia magna)
- perform experiments and undertake activities to gain an understanding of energy absorption, re-emission, radiation and dissipation that operate in the greenhouse effect, for example:

- measurement of the rise in temperature of samples of gases placed in direct sunlight or under a halogen lamp.

Biotic and abiotic surveys

use a number of techniques to assess biodiversity in the school or at a site in the local environment, for example, quadrats, transects, sampling; assess the biodiversity of that environment in a variety of measures such as number of species, species richness, species evenness, species diversity and endemism

design and perform experiments to compare the quality of different water samples: pH; temperature; dissolved oxygen content; total dissolved solids; nutrients in terms of nitrates, phosphates, sulfates; biological indicators in terms of various measures of macroinvertebrate or fish diversity

design and perform experiments to compare the quality of different soil samples: pH; salinity; total organic carbon content; particulate organic matter content; nutrients in terms of nitrates, phosphates, sulfates

conduct fieldwork to investigate environmental science concepts: choose a local area (for example, wetland, woodland, waterway or parkland) as the investigation focus; collect quantitative data on an abiotic factor (for example, intensity of light, proportion of shade/tree cover, and soil moisture) using transects and quadrats, and compare and collate class results; collect qualitative data about what you observed while collecting the quantitative data; if available, record the history of the use of the site; and to consider how the environment has changed over time

use remote sensing:

- access aerial photographs then go to site and calibrate- could be done before a field trip
- Google Timelapse: https://earthengine.google.com/timelapse/
- using ListMap to study Tasmanian geographical information: http://dpipwe.tas.gov.au/land-tasmania/the-list/listmap.

Suggestions for field trips

visit:

- Forestry Education Foundation- Contact Darcy Vickers at dvickers@netspace.net.au. Locations vary throughout state and overnight trips are also a possibility.
- Ashgrove/41 Degrees South to look at sustainable agriculture/aquaculture.

investigate:

- Roches Beach, Tessellated Pavement for rock platform
- Mt Field for changes in altitude, National Park management
- Hobart/Newtown Rivulet for water sampling, biotic and abiotic
- Northern Pacific Seastars in Derwent Estuary to cover introduced species (permit required from DPIPWE)

Suggested assessment tasks

write an in-class essay to analyse conflicting points of view and the range of values affected in current issues covered in the media (topic provided, bring in articles to reference). This task can also be used to assess Criterion 3

include a Criterion 4 component in the Case Study

participate in an online forum- each learner posts an issue and is required to post comments on at least 6 other issues.

## Detailed example

*How do fire, drought and flood affect the relative regeneration rates of indigenous, native and introduced plant species?*

Teachers must consider the management logistics of the investigation, taking into account number of learners, available resources and learner interest. The following questions require consideration:

- what input would learners have into the selection of the type of investigation undertaken (laboratory work, fieldwork or a combination of both)?
- what input would learners have into the selection of the investigation question?
- what input would learners have into the design of the experiment or fieldwork exercises?
- will different groups of learners in the class be able to undertake different investigations?
- is class data pooling a possibility?
- will off-school site work be involved?
- is the investigation reliant on particular weather conditions and/or accessibility constraints?

Teachers could provide learners with a template that structures the investigation into a series of timed phases. Learners may subsequently adapt the template as a personal work plan in their logbooks.

*Topic selection phase*

Discuss the effect of fire on indigenous, native and introduced tree species and whether other extreme climatic events had similar effects on plant regeneration. From this discussion learners should generate a question for investigation.

*Planning phase*

Learners may need guidance in:

- fitting the investigation into the time available, and developing a work plan
- identifying the independent, dependent and controlled variables in various experiments
- distinguishing between continuous and discrete variables
- developing hypotheses and distinguishing between a hypothesis, prediction and conclusion.

Teachers should work with learners to:

- identify and negotiate undertaking of various experiments by different learners or learner groups within the parameters of the question
- safely simulate conditions of 'fire'.

*Investigation phase*

Learner-designed methodologies must be approved by the teacher prior to learners undertaking practical investigations. A possible general management plan for the investigation follows:

- determine set of experiments and set up class recording grid, for example:

| | | |
|---|---|---|
| | | Number of germinated seeds |

| Seed treatment (N=20) | Time since planting (weeks) | Indigenous plant seeds | Native tree seeds | Introduced plant seeds |
|---|---|---|---|---|
| Untreated | 1 | | | |
| | 2 | | | |
| | 3 | | | |
| Fire-charred | 1 | | | |
| | 2 | | | |
| | 3 | | | |
| Sun-dried | 1 | | | |
| | 2 | | | |
| | 3 | | | |
| Water-soaked | 1 | | | |
| | 2 | | | |
| | 3 | | | |

- treat seeds (burning to simulate fire, drying to simulate drought and soaking in water to simulate drought) and set up growing conditions
- monitor weekly and record seed germination rates; monitoring times may need to be extended, dependent on when germination begins.

*Reporting phase*

Learners consider the data collected, report on any errors or problems encountered, and use evidence to explain and answer the investigation question. Differences in germination rates should be related to the type of seed being tested and the conditions to which the seeds were subjected.

Further avenues for investigation include:

- determining the effects on seed germination rates from other environmental events and conditions (for example, high humidity, acid rain)
- determining the effects of changed germination rates of seeds on the types of birds and insects attracted to a particular area.

The report of the investigation can take various forms including a written report, a scientific poster or an oral presentation of the investigation.

## Analyse the application and impact of environmental science in society

**Criterion 4** ***Examples of learning activities***

Learners:

explore issues such as salmon farming, use of ivory from elephants, climate change, Great Barrier Reef, any current issue in the news, whereby stakeholders can be identified,

role-play a Q&A panel type discussion to examine the possible implications (benefits and limitations) for stakeholders affected by development of a new site for mining an energy resource (panel members could be stakeholder representatives including: local resident with young family; local government representative; lawyer; environmental scientist; site worker from company contracted to carry out works; Aboriginal elder; town planner; environmental activist; philanthropist)

debate whether farming GM monoculture crops is preferable over farming polyculture crops (or whether pesticides alongside wild type monoculture crops if preferable over farming polyculture crops) for maintaining and growing populations that also build species resilience to changes in the environment

write a letter of appeal for urgent intervention and preventative action related to an issue from a stakeholders point of view

collect articles from newspapers illustrating issues and identify and evaluate different points of view, stakeholders and tensions

use a PMI (plus, minus, indifferent) to evaluate the roles/responsibilities of the media, scientists, celebrities in reporting climate change/promoting climate change action, for example Morgan Freeman (www.youtube.com/watch?v=8YQIaOldDU8) Leonardo DiCaprio www.youtube.com/watch?v=ka6_3TJcCkA and David Attenborough: The Truth About Climate Change (BBC - Part 2)

analyse Four Corners – 'Big Fish' for stakeholder positions and societal tensions.

### Detailed example

*A letter of appeal for intervention and preventative action*

*Introduction*

- Learners research a specific issue. They collate their findings in an electronic format and use these to compose a letter to the General Secretary of the UN/G20 appealing for urgent intervention and preventative action.
- Learners should be encouraged to examine a context that interests them personally.

*Science skills*

Teachers should identify and inform learners of the relevant key science skills embedded in the task.

*Prior learning*

Learners should be familiar with the following concepts prior to undertaking the activity:

- relevant ecological background
- relevant scientific aspects to the issue
- understand the nature of the tensions (ethical, political economic, cultural, social, aesthetic, scientific and educational)

*Procedure*

Stage 1

- Learners work individually or in small groups to research the context of one issue. Research findings should be recorded, including dates that the information was accessed and all sources of information; and any information updates.

Stage 2

- Learners use their documented research to help construct a letter (guided by subheadings) to the General Secretary of the UN/G20. The letter should use evidence to put forward the case and appeal for immediate intervention and preventative action over the next 20 years to minimise one or more of the predicted impacts of the issue.

## Apply ecological concepts and processes

**Criterion 5** ***Examples of learning activities***

| | |
|---|---|
| Photosynthesis | Learners: |
| | cover a section of leaf/variegated leaf with foil and then using an iodine test for starch as evidence of photosynthetic reaction; |
| | place a water plant in funnel in under water in beaker experiment to show oxygen evolution using a glowing splint to test for oxygen |
| | construct a table that compares examples of different organisms that utilise different methods of generating energy (photosynthesis, chemosynthesis, aerobic and anaerobic respiration); identify inputs and outputs of each energy-generating process |
| | construct a flow diagram (or re-sequence a mixed-up flow diagram) to link photosynthetic activity (plant growth cycle) with seasonal variation in atmospheric carbon dioxide levels |
| | grow seeds in dark and light (yellow vs green) |
| | investigate factors affecting productivity: light, CO2, water availability |
| | research the role of producers: autotrophs to convert light (or chemical in the case of S-systems) energy into chemical energy eg glucose |
| Food chains and webs | examine the role of:<br>o consumers: moving energy up the food chain (10%)<br>o decomposers: returning organic matter to inorganic nutrients |
| | investigate mould on strawberries over time; worm farm in an aquarium |
| | explore how energy flows through different types of ecosystems using an online simulation; see (modelling ecosystems) http://glencoe.mheducation.com/sites/0078695104/student_view0/unit1/chapter2/virtual_labs.html |
| | model how competition for natural resources between two species can affect population growth using an online simulator, for example at www.mhhe.com/biosci/genbio/virtual_labs/BL_04/BL_04.html |
| | explore an online interactive of the carbon cycle, for example http://sciencelearn.org.nz/Science-Stories/Harnessing-the-Sun/Sci-Media/Interactive/The-electromagnetic-spectrum |
| Relationship between species | explore and illustrate niche concept – biozone is a good resource |
| | construct a table to compare the different relationships between organisms providing examples of intraspecific competition (within one species); interspecific competition (across species); predation, parasitism , commensalism and mutualism |
| | explain the nature, roles, impacts and vulnerabilities of generalists and specialists in ecosystems |
| | explore the concept of ecological cascades: videos on wolves and whales available on YouTube |

Populations

map behaviour change and impact on kangeroos of drought using the video: Kangaroo Mob (https://www.youtube.com/watch?v=7ww3X0PKe4g)

investigate demographic variation by conducting a virtual experiment using an online simulation, for example at http://virtualbiologylab.org/PopGenFishbowl.htm

interpret graphical representation of population growth. For example: J and S shaped curves

use a systems approach to explore levels of organisation within the biosphere

**Detailed example**

*Terrestrial: Investigation Activity: Adaptations to Fire in the Tasmanian Forest System*

Using the resource: http://www.forest-education.com/wp-content/uploads/2017/07/fire_in_forests.pdf

Learners:

- compare and contrast a wet eucalypt forest with a dry eucalypt forest
- examine the number and type of trees present
- explore the impact fire has had on these forests and the adaptations the plants have developed as a result
- research and map the location of these two forest types in Tasmania and compare this with mainland Australia
- create a food web relevant to each forest type and show how they are different.

*Aquatic: Investigation Activity: Rock lobsters and long-spined sea urchin*

Learners:

- create a food web for the Tasmanian rock lobster
- explore how the size of a rock lobster is linked to its diet
- examine the impact fishing of rock lobsters has on kelp forests in terms of the population changes in long-spined sea urchins.

## Apply concepts and processes of ecosystem change

**Criterion 6** ***Examples of learning activities***

| | |
|---|---|
| Changes in climate | Learners:<br><br>how greenhouse gas (GHG) composition has changed in the Earth's atmosphere over time<br><br>sources of evidence for changes, such as ice cores from Antarctica/Greenland, monitoring atmospheric gases at Cape Grim and Mauna Loa, seasonal layers of calcium carbonate deposition in coral, sediment cores, tree rings, raised beaches revealing past sea levels, landforms due to ice age glaciation in the past<br><br>use the jigsaw research method to construct and share summary tables of the impacts to the survival of living things from the following cycles:<br><br>• ENSO and fire cycle at diurnal, seasonal and if relevant, tidal time periods<br>• 'How whales change climate' is a short video that discusses whales' role within the ocean ecosystem, including, their role in ocean mixing and ocean fertilisation, specifically iron, required by phytoplankton which then sink to the ocean floor, transferring carbon from surface waters to deep ocean sediments. Link to C5, C7, C8 https://www.youtube.com/watch?v=M18HxXve3CM.<br><br>view this documentary, Before the Flood (2016), can be accessed on YouTube<br><br>view videos of bubbling Siberian water bodies as permafrost melting discuss the significance of the change to ecosystems locally and globally (also has links to positive feedbacks in C5). E.g. https://www.youtube.com/watch?v=WKyRHDFKEXQ |
| Consequences of changes in atmospheric gas composition | various experiments to demonstrate ocean acidification:<br><br>• blow exhaled air into universal indicator solution and watch it change colour demonstrating carbonic acid formation as carbon dioxide from breath dissolves in water. Compare speed of colour change in tap water, distilled water and seawater.<br>• as above but with limewater.<br><br>demonstrate pH change due to CO2 dissolving in a 'hands-off'/no straws experimentt by suspending the cut-off bottom of a small paper cup inside the top of a clear plastic cup with indicator solution in the bottom. Place a small piece of dry ice in the top cup. As it sublimes it sinks (heavier than air), dissolves and changes the indicator solution colour<br><br>learner view online image collection – coccolithophores impacted by varying pH's to show ocean acidification impacts. Learner response: suggest impact/s of this on food chains... on sedimentation/long term storage of carbon in ocean sediments/rocks (chalk)… See resources at http://ocean.si.edu/ocean-acidification |
| Biodiversity and its importance | types of biodiversity (genetic, species, ecosystem)<br><br>the importance of each type of biodiversity<br><br>processes that threaten biodiversity, for example, habitat destruction and degradation, competition/predation and disease from introduced species, pollution, and climate change<br><br>investigate changes predicted to occur on an island over time using virtual biology simulations for island biogeography and plant diversity at http://virtualbiologylab.org/biodiversity-ecology/ |

mind map biodiversity evident in 'how wolves change rivers' (How Wolves Change Rivers), the how wolves were demonstrated to be important in structuring the bioidversity of Yellowstone National Park.

model the spread of fires using online simulaors http://sciencenetlinks.com/tools/wildfire-simulator and http://sciencelearn.org.nz/Contexts/Fire/Sci-Media/Interactive/Rural-fire-risk ; watch Catalyst episode www.abc.net.au/catalyst/stories/4014144.htm and discuss the relationships between fire and biodiversity.

## Detailed example

*Records of climate change*

*Introduction*

Brainstorm with learners:

- how we measure changes in climate today?
- what valid measurements are available from:
    - 50 years ago?
    - 100 years ago?
    - 200 years ago?
- how can we test the validity of older data?
- how might we use other data as a proxy for climate data?

*Research*

Learners will research and examine various methods of climate observation and analysis by Australian Bureau of Meteorology www.bom.gov.au/state-of-the-climate/ and:

- classify the data sources as:
- ice core 'proxy' data (for example, natural processes that record changing climate conditions in the absence of actual data)
- 'actal' data;
- describe how ice core and tree ring proxy data can be used to study climate change;
- outline limitations of using core and tree ring proxy data.

*Demonstration of knowledge*

Learners write a letter to a climate change sceptic:

- explaining the source and nature of the evidence for climate change
- describing what the limitations are of the data
- outlining why the data should be recognised as valid (within a margin of error)
- asking three questions designed to stump the chosen skeptic.

## Apply concepts relating to human dependence and impact on ecosystems

**Criterion 7** ***Examples of learning activities***

| | |
|---|---|
| Importance of ecosystem services | Learners:<br><br>participate in a class room debate about the benefits of development vs benefits of conservation after watching a stimulus such as: Jumbo Wild (https://www.youtube.com/watch?v=0XNBqe446uY)<br><br>discuss the definition and categories of biodiversity and their significance to ecosystem functioning and human survival<br><br>use practical work to investigate the role of moulds in ecosystem functioning and their importance in medicine<br><br>create an infographic to visually represent the ecosystem services provided by a particular ecosystem subtype (for example, tropical rainforest, coral reef, inland wetlands, mangrove swamps, and freshwater lake) including statistics/data from a reliable source presented in two or more different formats (for example, pie chart, map, frequency histogram, and table); include clear and obvious 'take home' messages and citations for all sources of information (for example, http://cdn4.kidsdiscover.com/wp-content/uploads/2013/08/Water-Cycle-Infographic-Kids-Discover.png or http://4.bp.blogspot.com/_x0WTeIsUNB0/S8IODhbpWtI/AAAAAAAAAFU/p0LKPsT4sOw/s1600/Infogram.jpg)<br><br>construct a SWOT (strengths/weaknesses/opportunities/threats) chart to consider an increased shift towards using renewable energy resources in relation to a current technological development, for example, 'Could our roofs become one big solar panel?' at www.theurbandeveloper.com/solar-panels-become-roof/<br><br>imagine being a researcher for an eco-solutions company that provides recommendations to consumers about everyday products; evaluate the environmental impact of one everyday product made from a non-renewable resource material compared to an alternative made from a renewable resource material, for example:<br><br>• drink bottle: plastic vs aluminium<br>• bag: plastic vs paper from biomass<br>• bag: plastic vs cloth from hemp/bamboo<br>• paint: traditional vs 'green' paint www.greenpainters.org.au/Consumer-Information/Sustainability.htm |
| Ecological Footprint | use an online ecological footprint calculator to calculate their own impact<br><br>work in teams to research the environmental impacts (consider energy usage, resources required, toxicity of materials, waste products, and impacts on flora, fauna and human societies) of selected products at each stage of the product's life cycle (sourcing raw materials; manufacture; distribution to end users; product use, reuse and maintenance; recycling, if any; and disposal); determine which material is 'better' for each life-cycle stage; from an environment stance, evaluate which is the better material, for this type of product overall<br><br>calculate absolute change (magnitude), percentage change and average rate of change in carbon dioxide concentrations during learner's time at secondary school (for example, approximately 5 years, from Jan 2010 – Jan 2015) using NASA data source http://climate.nasa.gov/vital-signs/carbon-dioxide/ |

| | |
|---|---|
| | examine the environmental practices used in Australia by Aboriginal peoples compared with non-Aborigines with respect to (for example) interaction with and dependence on Country, traditional knowledge and education, and cultural values |
| | select one of the following questions as a Think-Pair-Share brainstorming activity: What would the local community/Australian society/human civilization look like in the future if we were living sustainably? |
| Concepts relating to pollution | construct a Venn diagram using three intersecting circles to compare the definitions and features of wastes, contaminants and pollution |
| | organise a field trip to a recycling plant (for example, sewage, polymers, metal, household refuse) and summarise processes using a graphic organiser |
| | Eutrophication virtual lab<br>https://www.labster.com/simulations/eutrophication/?_sft_categories=biology |
| | debate the question, 'Is pollution inevitable?' |
| | design and perform an experiment to test the effectiveness of different methods for cleaning up oil spills or the effects of oil spills, for example responding to questions such as 'How can oil be removed most effectively from bird feathers?' or 'Can oil floating on a pond or dam be removed in the same way as oil spilled at sea?' or 'Does the salt in seawater affect how well an oil spill can be removed?' or 'Is oil spilled on water easier to remove than oil seeping into soils?' or 'Do different soils and rocks absorb oil to different degrees, and do they require different removal techniques?' |
| | investigate how DDT accumulates within organisms and magnifies up a food chain using a simulation, for example:<br>http://faculty.fmcc.suny.edu/freeman/webpages/environmentalscience/lab/BioaccumulationandBiomagnification.pdf |
| | annotate a map (for example, Google Earth, Google Maps) to indicate the geographic distribution of a pollutant from its source/s to its sink/s and identify the relevant transport mechanisms |
| | use a Project Based Learning (PBL) approach to investigate a question related to air, water or soil pollution |
| | create a possible food chain of organisms within an ecosystem relevant to a bioaccumulating pollutant; use concentration data (i.e. species with lowest concentration of pollutant likely at bottom of the food chain and species with highest concentration likely at top of food chain) |
| Impacts of resource use (food) | compare and contrast the impacts of aqua culture vs wild catch fisheries, and the differences between the quantity and the quality of each product using a site such as Macquarie Harbour, Tasmania to illustrate their ideas |
| | examine the impact of consumption of food by considering and analysing the claims in documentaries such as *The End of the Line* (http://thoughtmaybe.com/the-end-of-the-line/) or *Fillet-Oh!-Fish* (http://thoughtmaybe.com/fillet-oh-fish/) |
| | compare the use and impact of terrestrial food options with sea food options |

| | |
|---|---|
| Impacts of resource use (water) | find two sites pristine vs impacted looking at Biotic and Abiotic Factor and do a water quality assessment, invertebrate diversity assessment (looking at tolerant species) and investigate the difference and the cause<br><br>participate in and document field trips to the tip or sewage plant.<br><br>Investigate environmental flow – for example Meander Dam, or Murray River<br><br>complete a PMI (plus, minus, indifferent) organiser on the relative values of preserving an individual species versus its gene pool versus the ecosystem/s in which it lives (i.e. a 3 x 3 matrix)<br><br>provide examples of how the following act as threats to biodiversity: habitat modification and over-exploitation; genetic swamping, inbreeding and demographic variation due to small population size; loss of pollinators, dispersal agents, host species or symbionts; bioaccumulation; and competition from exotic species<br><br>devise a new way of measuring human or industrial environmental impact other than 'carbon footprint'<br><br>summarise and discuss main points in the video – '300 years of fossil fuels in 300 seconds', at www.youtube.com/watch?v=cJ-J91SwP8w<br><br>design and conduct an investigation to determine whether increased temperatures affect the reproduction rates of pest species and marine species<br><br>record the main points from the documentary *How Many People Can Live on Planet Earth* (https://documentarystorm.com/how-many-people-can-live-on-planet-earth/) |
| Impacts of resource use (energy production) | fact check a documentary *There's No Tomorrow* (https://www.youtube.com/watch?v=VOMWzjrRiBg), about 35 minute animation on fossil fuel use. Slightly depressing but an excellent summary of the issues- but worth fact checking some of the statistics as they are a few years old. |

## Detailed example

*Evaluation of two energy sources in a selected context*

*Introduction*

Learners research and compare energy sources with respect to the societal, economic and environmental advantages and disadvantages of their use. They annotate graphic organisers to present their analysis of energy source data and evaluate the sustainability of their use in a selected geographical context.

*Science skills*

Teachers should identify and inform learners of the relevant key science skills embedded in the task.

*Prior learning*

Learners should be familiar with the following concepts prior to undertaking the activity:

- Definitions of renewable, non-renewable, fossil, non-fossil with respect to energy sources
- Sustainability principles relevant to energy production and use.

*Procedure*

*Stage 1*

Learners analyse a range of energy source data. Points of comparison for energy sources might include data relating to:

- global abundance
- energy security considerations for Australia
- land use impacts
- cost to produce 1 kWh useable energy
- air emissions of $SO_2$, $NO_x$
- $CO_2$ emissions from 1 kWh useable energy.

Sample energy source data:

- www.geni.org/globalenergy/library/renewable-energy-resources/oceania/Solar/australia_files/solar-australia.gif
- http://si.wsj.net/public/resources/images/OG-AC575_electr_OR_20140915094435.jpg
- http://si.wsj.net/public/resources/images/OG-AC566_energy_G_20140912133724.jpg
- http://farm4.static.flickr.com/3036/2627670560_9667e8eca5.jpg?v=0.

*Stage 2*

- in small groups learners research and summarise various geographical contexts that have different energy needs with respect to (for example): demographics, topography, climate, transport networks, existing industries, and cultural considerations. Examples of geographic contexts include: an inland region of the Northern Territory, and a town on the west coast of Western Australia
- teachers may prepare a graphic organiser or template for learners to assist them in completing their analyses.

*Stage 3*

- learners draw on their prior analysis of energy source data to classify the outcomes of using TWO self-nominated energy sources at ONE self-nominated geographical context as either causing a positive or negative impact (including unintended consequences). They do this by summarising the positive impacts onto green post-it notes and the negative impacts onto pink post-it notes
- learners then place the coloured post-it notes into a three-circle Venn diagram for each energy source to categorise each impact as economic, social and/or environmental. Some impacts may fall under more than one label and should be placed in the overlap regions on the Venn diagram. This allows learners to semi-quantitatively evaluate the sustainability of using the two energy sources in a selected geographical context – generally the greater the number of green post-it notes, the more sustainable the energy source
- by considering the nature and number of positive and negative impacts of each energy source, learners can position each energy source along a 'sustainability continuum/scale' template and so visually represent their evaluation
- not sustainable ← ……→ sustainable
- learners compare, challenge and debate each other's positioning of their energy sources on the 'sustainability continuum/scale'.

*Discussion questions and report writing in logbook*

A series of questions should be set for learners to record, for example:

- Generalise: Where do renewable and non-renewable energy sources fall on the 'sustainability continuum/scale'? Illustrate your response on the continuum/scale.
- Infer: Are renewable energy source more sustainable than the non-renewable energy sources? Are fossil energy sources more sustainable than non-fossil energy sources? Which energy source is the most sustainable?
- Speculate: Would seasonal differences have an impact on the choice of energy sources within the selected geographical context?
- Relate: Describe one stakeholder likely to have a personal/professional investment in the outcomes of using energy sources at the nominated geographic location. What arguments might they put forward in support of the more sustainable energy source? What arguments might they have against using the more sustainable energy source?
- Extend: What are the predicted global impacts of using the less sustainable energy source over short, medium and long-term time scales?

*Teaching notes*

- For Stage 3 of this activity, learners should be encouraged to examine a context that interests them personally.

Note: Stage 3 of this activity could be adapted to form the basis of a formal assessment task. Teachers nominate TWO energy sources and ONE geographical context (real or imagined) and require learners to annotate two graphic organisers (approximately 50 minutes) to evaluate the suitability of the energy sources to meet the energy needs of the geographical context. Teachers may nominate two renewable energy sources OR one renewable and one non-renewable energy source OR one fossil and one non-fossil energy source.

## Apply principles and processes related to ecologically sustainable management of the environment

| **Criterion 8** | ***Examples of learning activities*** |
|---|---|
| Ecologically sustainable development | Learners:<br><br>locate various definitions of sustainable development (for example, definition from UNESCO: 'Sustainable development: development that meets the needs of the people today without compromising the ability of future generations to meet their own needs. To be sustainable, any use of resources needs to take account of the stock of resources and the impacts of its utilisation on the social, economic and political context of people today and in the future.' www.unesco.org/education/tlsf/extras/tlsf_glossary.html); copy each definifition onto a piece of butcher's paper; post up onto the classroom wall and identify similarities between definitions (in wording/ intention) and annotate butcher's paper; develop personal/class definition<br><br>use the document http://www.ecologia.com.au/environmental-management/environmental-management-plans/ to outline the differences between Environmental Impact Statements and Environmental Management Plans |
| Conservation of and preventing loss of biodiversity and ecological integrity | use Google Earth/Google Maps to locate one of Australia's biodiversity hotspots; identify the important habitat/s and important species present there; describe the conservation programs in place to maintain and preserve the location; discuss whether focusing on biodiversity hotspots is the 'key to preserving biodiversity'<br><br>generate primary and/or collect secondary data specific to a site to identify and assess the biodiversity of the environment: identify the threats to biodiversity at the site; suggest a strategy to reduce the threatening process<br><br>visit an organisation that is conserving biodiversity at a site and arrange a tour and presentation of their conservation strategy; summarise the strategy and examine its successes, issues and level of effectiveness |
| Environmental management | imagine being employed by the Australian Minister for the Environment as part of a team planning Australia's next national park; research possible locations for the park, describe how this location could preserve the values and benefits of biodiversity, propose ways in which different stakeholders might be affected, examine challenges that might be encountered and recommend ways in which these could be addressed |
| Other strategies for management | complete a three-circle Venn diagram to classify each sustainability principle as relating mainly to the environment, the economy or society. use visual stimuli such as photographs to name and briefly describe development projects occurring within the local/broader community (for example, new/upgraded swimming pool, roadworks or new apartment block); classify development using a three-circle Venn diagram showing whether each development project is primarily supporting environmental, social or economic needs and values; further classify into bearable (indicated by where social/environmental intersect in Venn diagram), equitable (social/economic intersect) or viable (economic/environmental intersect); identify some challenges faced by decision-makers due to competing interests of stakeholders for the selected development projects<br><br>comment on Ha-Joon Chang's quote from 23 Things They Don't Tell You About Capitalism (2010): 'People 'over-produce' pollution because they are not paying for the costs of dealing with it' |

discuss the differences between the following conservation categories: extinct in the wild, conservation dependent, critically endangered, endangered, and vulnerable

visit websites such as Ecology Links, Environment Australia and World Wildlife Fund, to research a program that is used to manage or conserve a species; identify what level or unit of conservation is being addressed by the program (for example, is it conserving genetic diversity, population/s or the entire species?); suggest why the conservation efforts are being concentrated at this level of conservation

Management of challenges to sustainability

select a topical environmental project that applies to one of the challenges above (population growth, agriculture, energy or water in Tasmania) undertaken by a business, an industry or a government agency and use it to study its environmental risks and impacts, how to reduce these risks and impacts; evaluate the effectiveness of the strategies implemented.

### Detailed example

*Analysis of a current management plan*

In an extended response outline, review and analyse a plan that is in place. Necessarily, each plan has unique components that need to be managed and will require some interrogation. Below can be found two Tasmanian examples:

Learners:

- consider the below while describing the typical content of a management plan, do you think there are any areas within the Wellington Park Management Plan (www.wellingtonpark.tas.gov.au/pdf/mngtplan2005.pdf) that are missing?
    - each of the six parts of the management plan
    - the five reasons given explaining why the area was initially reserved
    - the major values of Wellington Park under each of the following headings
    - the uses of the Park
    - the management goals
    - conflicting interests between tourism and water catchment management
    - at least one of the major threats to the park (fire, introduced species and vandalism) and their management
- analyse and comment on the effectiveness of the Tarkine Tourism Master Plan (http://www.cradlecoast.com/pdf/01201_TarkineTourismMasterPlan.pdf) with specific reference to the following:
    - the values of the Tarkine
    - the tourism context
    - the basis for the Tourism Master Plan
    - an assessment of the current tourism offerings
    - the Tourism Framework
    - tourism development
    - recreation management strategies
    - information, signage and interpretation
    - tourism management
    - implementation plan

# WORK REQUIREMENTS

## Case study

*General advice for teachers:*

- introduce the case study early so learners can develop their ideas right from the start
- encourage them to do something that they are re interested in
- where possible, include a C4 component as it's an excellent opportunity to assess this criterion
- provide exemplars from previous years
- brainstorm possible topics as a class
- have the learners to submit early - before requirements for other courses become an issue for them
- submit through plagiarism checking software
- require learners to submit drafts in order for the learners to gain feedback
- check in with the learners regularly, eg via Google Docs
- provide time in class for final write up

*Possible Topic Ideas*

Learners:

- conduct opinion surveys (eg meat consumption, plastic use, recycling habits) and relate to secondary data.
- calculate individual ecological footprints, with comparisons
- interviews with people from DPIPWE, CSIRO, UTAS, Forestry
- test water and relate to use of waterways (eg North Esk River) including biotic and abiotic testing
- design and conduct experiments to determine:
    - the minimum concentration of chlorine that will inhibit 50% of the growth of alfalfa seeds
    - how chemical water pollution affects plant growth
    - the factors that affect the pH of water in a local waterway
    - whether pesticides are equally effective on different types of pests
- investigate the biodiversity of ants in different ecosystems (ants may be baited and counted to obtain data with which to calculate the ant biodiversity of each chosen location, for example www.education.com/science-fair/article/ant-biodiversity/); compare measurements of biodiversity using species richness, Simpson's Index and the Shannon-Wiener Index
- conduct an experiment to investigate the effect different doses of chemicals have on the germination capacity of radish (or other fast-germinating) seeds; present results as a dose-response curve; chemicals could include plant food, sucrose, artificial sweetener, liquid laundry detergent, shampoo, carbonated water, household all-purpose cleaner, disinfectant, and salt
- collect biodiversity data relating to specific habitats within the school grounds by carrying out a BioBlitz/biodiversity scavenger hunt using two different sampling methods; establish a class blog page or start a new mapping project in iNaturalist or the GreatNatureProject (e.g. www.inaturalist.org/projects, http://greatnatureproject.org) to document results; collect and post digital photographs and identify habitats and species using field guides or online databases such as www.eol.org; extend this activity by evaluating the advantages and limitations of the sampling methods used and/or classifying the organisms identified as: demonstrating genetic variation within a population, being threatened or introduced species, demonstrating predation, being examples of reproductive isolation, being pollinators, or being dispersal agents
- for practical investigations Student Riskassess (https://www.riskassess.com.au/info/student) can be used collaboratively between learner, laboratory manager and teacher. The learner can then quickly complete a risk assessment for their investigation.

## Detailed example

*How does the dosage of a pollutant affect germination of radish seeds?*

*Use this investigation as a Case Study*

Learners are required to perform these experiments in a broader context meeting the Work Requirements from the Case Study (see Course Document - https://www.tasc.tas.gov.au/students/courses/science/ess315118/), This will necessarily mean that:

- learners have some autonomy and what is suggested below is only a guide
- the analysis and discussion of the results will be more detailed and in-depth than for a practical investigation to meet the Work Requirement for Practical Work (see Course Document - https://www.tasc.tas.gov.au/students/courses/science/ess315118/)

*Sample aim*

To investigate the effect of changing dosages of a non-bioaccumulating water-borne chemical pollutant on the germination capacity of radish seeds.

*Prior learning or research required*

- learners should be familiar with the following concepts and skills prior to undertaking the activity:
- defining the term 'water-borne pollutant' and listing some examples
- examining chemical components/structure/characteristics of the selected chemical for the investigation
- mapping the geographic location/s of sources, dispersal, sinks of the selected chemical
- hypothesising under which conditions the selected chemical could be classed as a pollutant
- identifying potential sources of the selected chemical (for example, industrial waste, sewage and waste water, mining activities, burning of fossil fuels, agricultural waste including fertilisers and animal waste, urban development including landfill)
- completing/reviewing a safety data sheet (SDS) for using the selected chemical in a school laboratory
- sourcing acceptable limits of chemicals based on toxicological studies, including expressing these limits as a dosage
- researching how toxicity tests enable toxicologists to learn about responses of living organisms to doses of chemicals (dose-response relationships).

*Example of preparation required*

- technical support prepares relatively concentrated stock solutions of selected chemical 'pollutant' (for example, solid chemicals could be dissolved to approximately 50% w/v in water)
- safe, easily available chemicals to select from could include: ethanoic acid, acetone, methanol, ethanol, laundry detergent, disinfectant / household all-purpose cleaner, shampoo, plant food, salt, window cleaner
- 2.5 mL volumes of various concentrations of the chemical are supplied for the class (for example, 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%). Each group of learners selects any five variations in concentration for their experiment; ideally one of these should be a zero concentration of the chemical to act as a control sample
- depending on the class size, replicates of each sample could be set up; learners could average the data obtained as part of their analysis
- in addition, each learner group also requires seeds soaked overnight in water in the dark, paper towels/ cotton wool pads to provide a germination surface within the Petri dishes, 5 small Petri dishes with lids, a spoon, deionized water in spray bottles, indoor access to sunlight, magnifying glasses / digital camera with zoom.

*Health, safety and ethical notes*

- the chemicals selected are common household products. Standard laboratory safety measures should be followed
- there are no ethical issues

*Procedure*

- collect materials for their group including five different concentrations of the selected chemical 'pollutant'
- spray the bottom of the Petri dishes with a little water to help the cotton wool pads to stick
- place a cotton wool pad into the base of each Petri dish
- administer the different dosages of the selected chemical by pouring the 2.5 mL volumes of chosen concentrations onto the pads
- using the spoon, carefully distribute about 20 pre-soaked seeds onto the pad
- cover the Petri dishes with their lids and place in a warm, well-lit location
- construct a table that best represents the results to be collected in the logbooks
- lightly spray the seeds with water during the experiment as needed. The cotton wool pad should be just damp and not soaking. Learners could collect qualitative and quantitative data over multiple days, which may include: time measurements, measurements of root / shoot / root hair growth, % germination, photographs/time-lapse images, sketches. If replicate samples are set up, then learners could average the data collected. Learners could analyse the data by constructing a dose-response curve. If the experiment is continued until all the germinated seedlings die, then it may be possible to deduce an LD50 from interpolating the curve

*Teaching notes*

Radish seeds will require about three to four days to germinate. The experiment could be set up on a Monday and then monitored mid-week and end of week for percentage germination. Learners may opt to monitor their seeds daily. Seeds can be considered ungerminated after eight days of no growth. If learners are collecting data about growth rates then sufficient data can be obtained over about a seven-day period following germination.